PURE FOODS

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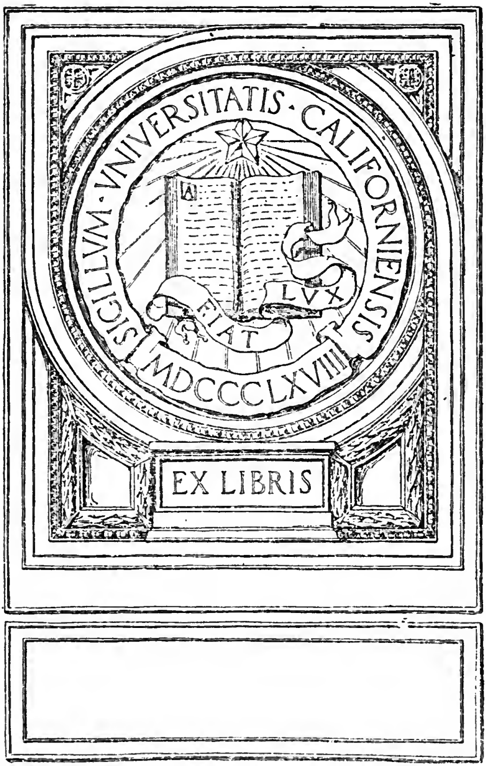
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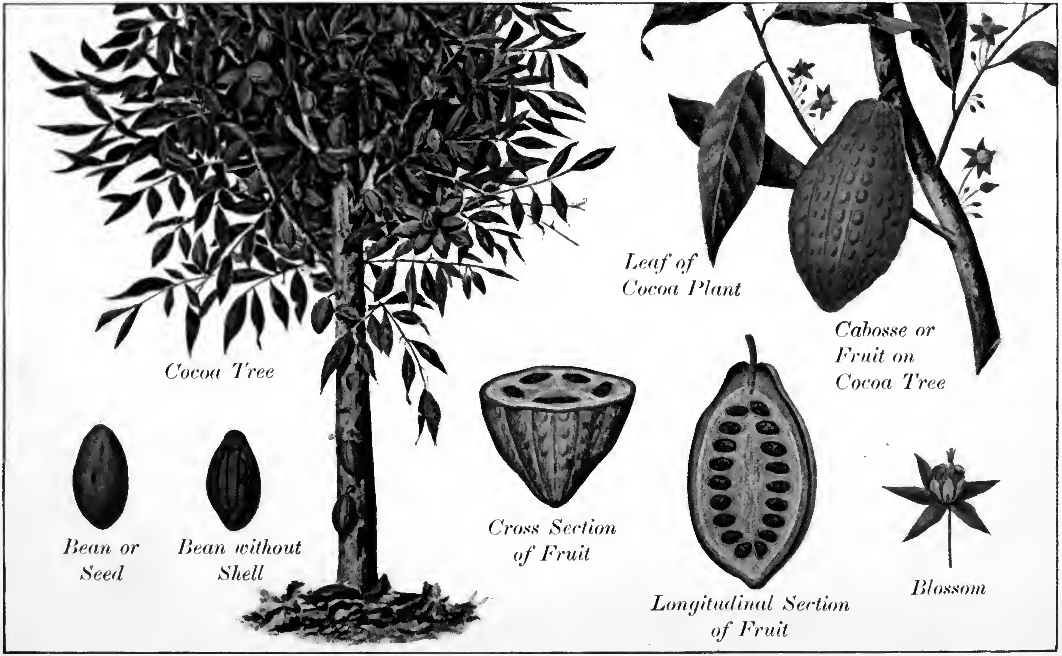

THE COCOA TREE AND ITS FRUIT

PURE FOODS

THEIR ADULTERATION, NUTRITIVE VALUE, AND COST

BY

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"CHEMICAL ANNUAL," ETC.

GINN AND COMPANY
BOSTON · NEW YORK · CHICAGO · LONDON

814.2

The Athenæum Press
GINN AND COMPANY · PROPRIETORS · BOSTON · U.S.A.

PREFACE

This volume is the outgrowth of a series of public lectures on foods, which have been given by the author for a number of years. The interest shown by audiences of widely different character, as well as frequent requests for the substance of the lectures in printed form, has led to their publication. The experimental illustrations which accompanied the lectures are given in the form of a series of experiments at the end of each chapter. Some of these experiments are so simple that they may be carried out with ordinary household utensils, others require a few chemicals and simple apparatus which may be purchased at any drug store. Many of them require a fairly well-equipped chemical laboratory, while others have been included which can be performed only by those who have considerable chemical training and facilities at their command. Most of the descriptive matter can be understood by the average intelligent reader, although even here a knowledge of chemistry will enable the reader to comprehend the subject much more fully.

It is the hope of the author that this volume will be of some service to the very important class of teachers and students who are studying the chemistry of foods in the classroom and laboratory. It is hoped that the subject has been presented in such a manner as to stimulate the interest of such classes, and that domestic-science teachers will be able to explain and expand the necessarily brief expressions of the text, as well as perform such experiments as are beyond the ability of the student. The author also hopes that the volume will be of service to the growing class of intelligent men and women who desire to obtain some knowledge of the composition and function of the foods which they prepare, sell, or consume.

Of the great need of a wider and fuller knowledge of the nature and functions of the food which is of such vital necessity to us, the author has the keenest realization. In an age when intelligence and knowledge are recognized as essential to the most efficient performance of even very simple tasks, it is surprising that most of us eat what we like, with very little thought of the ultimate result.

The steel for our bridges and buildings is bought and sold on the chemist's certificate of its composition to the thousandths of per cent. Foods are manufactured and sold on flavor and appearance, utterly regardless of composition or food value. The coal for our engines must be tested and analyzed, but the far more precious human organism is loaded with a heterogeneous mixture of fuel of unknown composition. We should not be surprised at low efficiency, inability to work, sickness, even the premature death of an organism which is given so little intelligent care. When an intelligent, well-informed public demands analyzed, tested foods, they will be better served by the food producer, manufacturer, and salesman; and if such food is consumed in the physiologically proper quantity and variety, there will be far less inefficiency, sickness, and mortality.

The author does not claim originality for any appreciable portion of this volume. For most of the general facts and ideas presented he is indebted to the large army of municipal, state, and national pure-food workers, who have accumulated so much valuable information on this subject.

The coming generations will reap large harvests of comfort and well-being from their quiet but effective work.

The author wishes to express his indebtedness to many of these workers whom it has been his good fortune to know personally, and also to many others whom he knows only through their publications. Statements made with reference to the actual conditions of our food supply are generally based, at least in part, on the author's tests of foods in the course of his consulting practice as a chemist, and on the results of investigations carried out to ascertain the composition of the foods on the market. He need hardly say that this volume was not written to meet the needs of the technical chemist.

The author takes great pleasure in expressing his obligation to Mr. Albert E. Seeker, of the United States Department of Agriculture, for reading the entire manuscript and making many valuable suggestions. He is also under obligations to Mr. H. C. Humphrey of the Corn Products Refining Company for reading the chapters on Carbohydrates and Candy.

J. C. OLSEN

BROOKLYN, NEW YORK

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CHAPTER I

WHAT IS FOOD?

The animal instinct known as appetite has for ages answered this question. As man developed intelligence he learned to avoid eating certain plants or animals which produced illness or death, even though they tasted good. Still more slowly he acquired crude and often erroneous notions of the nutritive value of the wholesome foods. Very little progress has been made until recently in the attempt to regulate the amount and proportion of the various foods consumed. Most civilized nations have generally overcome the dietary methods by which primitive races have alternated between gluttonous indulgence when food was plenty and starvation and want at other times. Only the very wonderful ability of the human system to adapt itself to great extremes in the kind and amount of food consumed has enabled man to retain his vigor while eating as a savage. The unsanitary condition of the food supply has resulted in the introduction into the human system of innumerable disease bacteria. Under these conditions the sacrifice of life has been appalling, especially among the immature, aged, and sick.

Composition of foods. Rapid strides have recently been made toward attaining a scientific answer to the question as to what constitutes food. The chemist has analyzed the various organs of the human system and discovered that they are in the main composed of but four chemical elements; namely, carbon, hydrogen, oxygen, and nitrogen. Substances composed mainly of these four elements are called *organic matter*. The bones and teeth consist largely of calcium, phosphorus, silicon, and oxygen, while the blood contains considerable quantities of iron and common salt, which is a compound of sodium and chlorine. These chemical elements as a group are called *mineral matter*. As compounds of these elements are constantly leaving the body, it is evident that to maintain the body weight these elements must constitute the bulk of our food, which must also be composed of such compounds of these elements as can be readily digested and assimilated. There are four large classes of chemical compounds which have been found to meet these requirements and to constitute the bulk of our foods; namely, carbohydrates, fats, protein, and mineral matter.

Carbohydrates are composed of carbon, hydrogen, and oxygen. This class may be subdivided into cellulose, starch, and sugar. Cellulose is a very insoluble substance, and is the main constituent of wood and vegetable fibers, such as cotton and linen. It is not suitable for food on account of its insolubility. The starches are also very insoluble compounds. They constitute a large part of most seeds and grains. When the grain sprouts, the starch is rendered soluble so that it can be dissolved by the sap and nourish the growing plant. If the grain is eaten by man, a similar transformation takes place during digestion, rendering it possible for the soluble carbohydrate produced to dissolve in the blood, which carries it to all parts of the system. As cellulose cannot be rendered soluble in this manner, it is not suitable for food.

Sugars. When starch is rendered soluble it passes sooner or later into some form of *sugar.* About two hundred different sugars have been discovered by chemists. Only a few of these are present in any large quantity in ordinary foods. Cane sugar is the most common of these and is most highly prized as a food on account of its sweet taste. It is extracted in large quantities from the juice of the sugar cane, sugar beet, and maple tree. When starch is rendered soluble it passes into other sugars which are less sweet, such as dextrose and maltose. They are fully as nourishing as cane sugar and pass into the blood more quickly because cane sugar must first be broken up into two simpler sugars called dextrose and levulose.

Solubility of the carbohydrates. The chief difference, therefore, between these three classes of carbohydrates is found in their solubility. This property is of fundamental importance in a food. The body cannot be nourished by cellulose because the juices of the body cannot dissolve it. Starch can be rendered soluble and can therefore, after digestion, nourish the body, while the sugars are almost instantly taken into the circulation, giving immediate relief from exhaustion. These three classes of carbohydrates contain the same three chemical elements in almost exactly the same proportion (carbon, 44.4 per cent; hydrogen, 6.2 per cent; and oxygen, 49.4 per cent). The same chemical formula [$(C_6H_{10}O_5)^x$] is used to represent cellulose, starch, and dextrin, which indicates that the chemical elements are present in the same proportion (C represents carbon, H hydrogen, and O oxygen). The formula for dextrose (grape sugar) and levulose is $C_6H_{12}O_6$. This formula differs from that of starch by H_2O. As H_2O is also the formula for water, the transformation of starch into dextrose consists in the addition of water, and has therefore been called hydrolysis and may be represented by the following chemical equation:

$$C_6H_{10}O_5 + H_2O = C_6H_{12}O_6.$$

Cane sugar, as well as maltose, is represented by the formula $C_{12}H_{22}O_{11}$, and also differs in composition from starch by the elements of water, as is seen from the following equation:

$$2\,C_6H_{10}O_5 + H_2O = C_{12}H_{22}O_{11}.$$

The fats and oils constitute another of the four large classes of foods. These substances are also composed of the three elements, carbon (about 76.5 per cent), hydrogen (about 11.9 per cent), and oxygen (about 11.5 per cent). They differ from the carbohydrates in that they contain a much smaller proportion of oxygen. They are also more complex in structure, being composed of glycerin combined with fatty acids. When fats become rancid these acids are liberated, giving disagreeable odors and tastes.[1] During the process of digestion the glycerin is separated from the fatty acids. After absorption by the blood these constituents are again united to form the characteristic fats of the human system. A small portion of the fat is divided into very minute globules which will remain suspended in the digestive fluids, producing a liquid similar to milk. The animal fats are so similar to each other and to vegetable fats that the lard from hogs fed on cottonseed meal will give a test for cottonseed oil, indicating that at least a portion of this oil has been deposited unchanged in the tissues of the animal.

The proteins constitute the third large class of foods. They contain the same three elements as the two preceding

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[1] The presence of free acid alone does not constitute rancidity (some acid oils not being rancid), but a rancid condition is the result of complex changes effected by the action of light and air on oils, causing at the same time the formation of free acid, so that all rancid oils are acid, but not all acid oils are rancid.

classes, but in addition contain considerable quantities of nitrogen (about 16 per cent) as well as small quantities of sulphur and phosphorus. Examples of this class of foods are the lean portions of meat, the white of eggs, and the gluten of wheat. The proteins are of importance in the human diet almost solely on account of their content of nitrogen. As the living cells of the body cannot be built up or nourished on any other food but proteins, it is evident that this class of foods is of vital necessity to the human system. Fats and carbohydrates can, to a certain extent, replace each other in the human diet, but neither of these can replace protein matter; neither can the human system assimilate nitrogen in any other form than protein. Most proteins are readily dissolved by the gastric juice of the stomach and the digestive fluids of the intestines. During this process the proteins are broken down into a simpler class of nitrogenous compounds called peptones. The peptones differ from the proteins in that they are more soluble; for instance, a protein such as white of egg is precipitated by boiling, while a peptone would not be affected by this treatment.

Mineral matter which constitutes the fourth class of foods is present in small amount in almost all portions of animals and vegetables which are used as food. When foods of this kind are burned, the carbon, hydrogen, oxygen, and nitrogen pass off as gases, while the mineral matter remains as a solid and is known as the *ash*. The amount of ash obtained from a given food is a measure of the amount of mineral matter present. If the ash were eaten, only a small portion would dissolve and be available for nourishing the system. The mineral constituents are in such a form of combination in animal and vegetable matter that they can be dissolved by the blood and deposited in the bones or teeth where needed. Most natural waters contain a small but appreciable amount of mineral matter which is already in solution, ready for absorption. If present in unusual amount, the water is used expressly for its mineral content and is called a mineral water.

It is evident, therefore, that *a food must consist of readily soluble compounds containing the same chemical elements which are found in the human system.*

Food as a source of energy. While food is utilized to build up the various organs of the human system and repair waste, it must also serve some very different purpose because such large quantities are digested and taken into the circulation and then expelled again.[1] Investigation shows that the chemical elements do not pass out in the same form of combination in which they enter the system. The greatest difference is found in the amount of oxygen in combination with the carbon and hydrogen. These elements enter the system combined with very little oxygen, and pass out in combination with the maximum quantity for these elements; that is, as carbon dioxide and water.[2] It has been demonstrated that this oxygen is taken from the air which enters the lungs. Whenever carbon or hydrogen combine with oxygen a large amount of heat is evolved. When food is oxidized in the human system this heat is liberated and is utilized for maintaining the normal temperature of the body. Heat can also be transformed into other forms of energy. The steam engine, for instance, transforms the heat obtained by burning the coal into mechanical energy, which moves trains or does other useful work. In the same way the energy obtained from the food

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[1] A child in growing to manhood consumes from 15 to 20 tons of food.

[2] Hydrogen forms a higher oxygen compound than water (H_2O), but this compound (hydrogen peroxide, H_2O_2) cannot exist in contact with animal tissues.

is used in the body to perform muscular work, and to keep up the circulation of the blood and other activities of the various organs. The system requires in the aggregate a very large amount of energy for its various activities, all of which is obtained from the food. We may therefore define food as follows:

Food must consist of readily soluble compounds containing the same chemical elements which are found in the human system, and a considerable amount of energy which can be liberated by oxidation.

Functions of food. It is evident, therefore, that the food serves two functions in the animal body. It serves as the material from which the animal structure is built, and it also furnishes the energy to keep up the bodily activities and temperature, the greater part of the food being used for the latter purpose only. The marvelous economy of nature is shown in the fact that when any portion of the animal structure is worn out and is ready to be discarded, it is first decomposed in such a way that its available energy is first utilized by the system. Every particle of food, therefore, which is dissolved by the blood gives up its energy before it is again eliminated. The energy content of the food is therefore the simplest criterion of its value. That the taking of food gives strength and energy to the human system is a matter of everyday experience. Scientific investigation has shown how the energy value of a given food can be accurately measured.

The calorie. As all forms of energy can be transformed into each other, it is only necessary to measure the energy given out by a food in one of these forms. The heat evolved when the food is burned can be readily measured. For this purpose the heat is absorbed by water and the increase in temperature noted. It is evident that with unequal quantities of heat the same amount of water will be raised to the highest temperature by the largest amount of heat. In other words, the temperature to which a given quantity of water is raised will be a measure of the amount of heat evolved. The quantity of water used is one kilogram, which at ordinary temperatures is very nearly equal to one liter, or 1.05668 quarts. The Centigrade scale is used for measuring the rise in temperature. The amount of heat necessary to raise one liter of water one degree Centigrade is called a *Calorie.*

The calorimeter. For determining the energy value of foods, a weighed quantity of the food is placed in a hermetically sealed bomb, which is filled with oxygen under pressure. The bomb is immersed in two liters of water, the temperature of which is taken by means of an accurate thermometer. A platinum wire in contact with the food is then fused by means of an electric current so as to ignite the food which burns in the oxygen surrounding it. The heat is absorbed by the water, which is kept in constant motion by means of a stirring device. The highest temperature reached by the thermometer is carefully noted and the number of Calories evolved is calculated, a correction being introduced for the heat retained by the bomb and the vessel holding the water. During the experiment the vessel containing the water and the bomb is protected from loss or absorption of heat by insulating covers. The energy value obtained in this manner is called the *calorific value* of the food. The instrument used is called a *calorimeter.*

[1] Using an ordinary (Fahrenheit) thermometer, a Calorie would be very nearly equal to the heat necessary to raise the temperature of one quart of water two degrees. A much smaller unit, known as the small calorie, is also in use. It is the amount of heat necessary to raise the temperature of one cubic centimeter of water one degree Centigrade. A liter contains 1000 ccm. (In order to distinguish these units from each other, the large Calorie is spelled with a capital C and the small calorie with a small letter. The calorific value of foods is generally given in large Calories.)

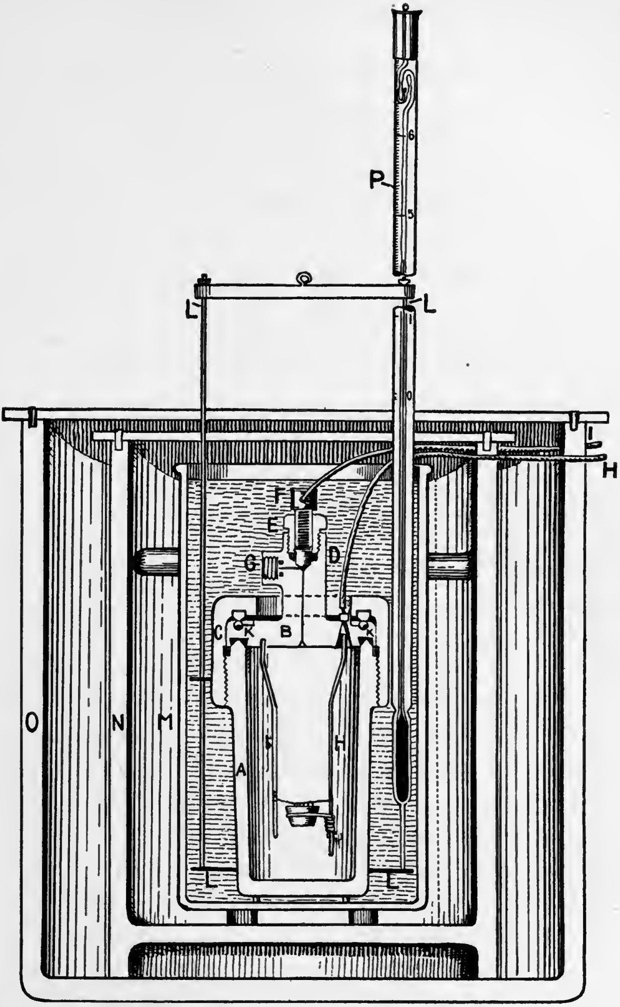

Fig. 1. Atwater-Mahler Bomb Calorimeter

A, bomb immersed in water; *B*, cover; *C*, screw-cap; *G*, screw connection for attaching to oxygen tank; *H*, *I*, wires for conducting the electric current for ignition of food placed in platinum cup; *KK*, ball-bearings of hard steel to avoid friction in screwing cup down; *L*, stirring device; *N*, *O*, insulating vessels to prevent loss of heat; *P*, thermometer

The calculation of calorific value. As the calorific value of the protein (5.7), fats (9.3), and carbohydrates (4.1) has been carefully determined, the calorific value of a given food may be calculated if its chemical composition has been determined. In making such a calculation the value found for protein in the calorimeter is not used, because this constituent of foods is not completely oxidized in the human system. The value 4.1 is therefore used, which represents the amount of heat evolved in the body. The following values are therefore used in calculating the calorific value of a food:

Protein	4.1 large calories per gram
Carbohydrates	4.1 large calories per gram
Fats	9.3 large calories per gram

It is evident from this table that we obtain the greatest amount of heat and energy from fatty foods, but because such foods are not easily digested by most people, carbohydrates are generally consumed in large enough quantities to furnish a great deal of the requisite amount of energy. By far the most common carbohydrate is starch, so that starchy foods constitute the bulk of our diet. Because protein matter is not completely oxidized, it cannot serve economically as a source of energy, and as the elimination of its decomposition products from the system by the liver and kidneys involves considerable effort, producing disorders of various kinds, it should not be consumed in quantities greater than necessary to keep the tissues of the body in good condition. The statement that olive oil has a calorific value of 4220 means that when one pound of the oil is burned, 4220 calories of heat are liberated. The calorific value of sirloin steak is only 1130 because it contains 62 per cent of water, which gives no energy to the system, its function in a food being simply to hold soluble matter in solution, rendering digestion more easy.

Composition of foods. It is evident that the essential characteristics of a food can be indicated by giving the percentage of water, mineral matter, fat, carbohydrates, and protein present, as well as the calorific value. The following table gives this data for the edible portion of a number of common articles of food. The foods are in the raw state unless otherwise designated.

TABLE I

Composition and Calorific Value of Common Foods

Food as purchased	Refuse	Water	Protein	Fat	Carbo-hydrates	Mineral matter	Calorific value
Beef	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Calories*
Corned	8.4	49.2	14.3	23.8		4.6	1245
Porter-house steak . .	12.7	52.4	19.1	17.9		0.8	1100
Sirloin steak	12.8	54.0	16.5	16.1		0.9	975
Round steak	7.2	60.7	19.0	12.8		1.0	890
Ribs	20.8	43.8	13.9	21.2		0.7	1135
Rump	20.7	45.0	13.8	20.2		0.7	1090
Lamb							
Leg, hind	17.4	52.9	15.9	13.6		0.9	860
Mutton							
Leg, hind	18.4	51.2	15.1	14.7		0.8	890
Loin chops	16.0	42.0	13.5	28.3		0.7	1415
Pork							
Bacon, smoked	7.7	17.4	9.1	62.2		4.1	2715
Ham, fresh	10.7	48.0	13.5	25.9		0.8	1320
smoked	13.6	34.8	14.2	33.4		4.2	1635
Loin chops	19.7	41.8	13.4	24.2		0.8	1245
Salt pork		7.9	1.9	86.2		3.9	3555
Tenderloin		66.5	18.9	13.0		1.0	895

TABLE I (Continued)

Composition and Calorific Value of Common Foods

Food as purchased	Refuse	Water	Protein	Fat	Carbohydrates	Mineral matter	Calorific value
Veal	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Calories*
Breast	21.3	52.0	15.4	11.0		0.8	745
Leg	14.2	60.1	15.5	7.9		0.9	625
Leg cutlets	3.4	68.3	20.1	7.5		1.0	695
Poultry							
Chicken, broilers . . .	41.6	43.7	12.8	1.4		0.7	305
Turkey	22.7	42.4	16.1	18.4		0.8	1060
Fish							
Cod, fresh, dressed . .	29.9	58.5	11.1	0.2		0.8	220
salt	24.9	40.2	16.0	0.4		18.5	325
Halibut, steak or sections	17.7	61.9	15.3	4.4		0.9	475
Lobsters	61.7	30.7	5.9	0.7	0.2	0.8	145
Mackerel, whole . . .	44.7	40.4	10.2	4.2		0.7	370
Oysters, "solids" . . .		88.3	6.0	1.3	3.3	1.1	225
Perch, yellow, dressed .	35.1	50.7	12.8	0.7		0.9	275
Salmon, canned . . .		63.5	21.8	12.1		2.6	915
Shad, whole	50.1	35.2	9.4	4.8		0.7	380
Eggs and Dairy Products							
Butter		11.0	1.0	85.0		3.0	3410
Cheese, full cream . .		34.2	25.9	33.7	2.4	3.8	1885
skim milk . .		45.9	31.5	16.5	2.0	4.1	1320
Cream		74.0	2.5	18.5	4.5	0.5	865
Eggs, white		86.3	12.8	0.4		0.5	250
yolk		50.0	16.0	33.0		1.0	1705
whole	11.2	65.5	13.1	9.3		0.9	635
Milk, whole		87.1	3.2	4.0	5.0	0.7	325
skimmed		90.5	3.4	0.3	5.1	0.7	165
butter		91.0	3.0	0.5	4.8	0.7	160
condensed . . .		26.9	8.8	8.3	54.1	1.9	1430
Cereals							
Barley		11.9	10.3	2.0	73.3	2.5	1640
pearled		11.3	8.4	1.0	78.3	1.0	1650
Buckwheat flour . . .		13.6	6.4	1.2	77.9	0.9	1605

TABLE I (Continued)

Composition and Calorific Value of Common Foods

Food as purchased	Refuse	Water	Protein	Fat	Carbohydrates	Mineral matter	Calorific value
Cereals (Continued)	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Calories*
Corn meal		12.5	9.2	1.9	75.4	1.0	1635
Graham flour		11.3	13.3	2.2	71.4	1.8	1645
Macaroni, vermicelli, etc.		10.3	13.4	0.9	74.1	1.3	1645
Oatmeal		7.7	16.7	7.3	66.2	2.1	1800
Rice		12.3	8.0	0.3	79.0	0.4	1620
Rye flour		12.9	6.8	0.9	78.7	0.7	1620
Wheat flour, patent roller process							
high grade and med.		12.0	11.4	1.0	75.1	0.5	1635
low grade		12.0	14.0	1.9	71.2	0.9	1640
whole wheat		11.4	13.8	1.9	71.9	1.0	1650
Bread and Pastry							
Bread, brown		43.6	5.4	1.8	47.1	2.1	1040
graham		35.7	8.9	1.8	52.1	1.5	1195
rye		35.7	9.0	0.6	53.2	1.5	1170
white		35.3	9.2	1.3	53.1	1.1	1200
whole wheat		38.4	9.7	0.9	49.7	1.3	1130
Cake		19.9	6.3	9.0	63.3	1.5	1630
Oyster crackers		4.8	11.3	10.5	70.5	2.9	1910
Soda crackers		5.9	9.8	9.1	73.1	2.1	1875
Vegetables							
Beans, baked		68.9	6.9	2.5	19.6	2.1	555
dried		12.6	22.5	1.8	59.6	3.5	1520
Lima, shelled		68.5	7.1	0.7	22.0	1.7	540
string	7.0	83.0	2.1	0.3	6.9	0.7	170
Beets	20.0	70.0	1.3	0.1	7.7	0.9	160
Cabbage	15.0	77.7	1.4	0.2	4.8	0.9	115
Celery	20.0	75.6	0.9	0.1	2.6	0.8	65
Corn, sweet, green, edible portion		75.4	3.1	1.1	19.7	0.7	440
canned		76.1	2.8	1.2	19.0	0.9	430

TABLE I (CONCLUDED)

COMPOSITION AND CALORIFIC VALUE OF COMMON FOODS

Food as purchased	Refuse	Water	Protein	Fat	Carbohydrates	Mineral matter	Calorific value
Vegetables (Continued)	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Calories*
Cucumbers	15.0	81.1	0.7	0.2	2.6	0.4	65
Lettuce	15.0	80.5	1.0	0.2	2.5	0.8	65
Mushrooms		88.1	3.5	0.4	6.8	1.2	185
Muskmelons	50.0	44.8	0.3		4.6	0.3	80
Onions	10.0	78.9	1.4	0.3	8.9	0.5	190
Parsnips	20.0	66.4	1.3	0.4	10.8	1.1	230
Peas, dried		9.5	24.6	1.0	62.0	2.9	1565
shelled		74.6	7.0	0.5	16.9	1.0	440
green, canned		85.3	3.6	0.2	9.8	1.1	235
Potatoes, Irish	20.0	62.6	1.8	0.1	14.7	0.8	295
sweet	20.0	55.2	1.4	0.6	21.9	0.9	440
Spinach		92.3	2.1	0.3	3.2	2.1	95
Squash	50.0	44.2	0.7	0.2	4.5	0.4	100
Succotash, canned		75.9	3.6	1.0	18.6	0.9	425
Tomatoes		94.3	0.9	0.4	3.9	0.5	100
canned		94.0	1.2	0.2	4.0	0.6	95
Turnips	30.0	62.7	0.9	0.1	5.7	0.6	120
Watermelons	59.4	37.5	0.2	0.1	2.7	0.1	50
Fruits							
Apples	25.0	63.3	0.3	0.3	10.8	0.3	190
Apples, dried		28.1	1.6	2.2	66.1	2.0	1185
Apricots, dried		29.4	4.7	1.0	62.5	2.4	1125
Bananas	35.0	48.9	0.8	0.4	14.3	0.6	260
Dates, dried	10.0	13.8	1.9	2.5	70.6	1.2	1275
Figs, dried		18.8	4.3	0.3	74.2	2.4	1280
Grapes	25.0	58.0	1.0	1.2	14.4	0.4	295
Lemons	30.0	62.5	0.7	0.5	5.9	0.4	125
Oranges	27.0	63.4	0.6	0.1	8.5	0.4	150
Pears	10.0	76.0	0.5	0.4	12.7	0.4	230
Raisins	10.0	13.1	2.3	3.0	68.5	3.1	1265
Raspberries		85.8	1.0		12.6	0.6	220
Strawberries	5.0	85.9	0.9	0.6	7.0	0.6	150

EXPERIMENTS

1. Starch test. Place a gram or two of starch in a beaker or porcelain mortar, add a little water, and stir so as to make a thin paste. Stir the starch paste, while pouring on it 100 ccm. of boiling water. Dilute the solution with an equal volume of water. Place a few cubic centimeters of the starch solution in a beaker or test tube and add a few drops of iodine solution.[1] The blue color produced is a very delicate test for starch. Various articles of food may be tested in this manner for starch, such as flour, potatoes, vegetables, etc. The test may sometimes be obtained without boiling with water.

2. Test for reducing sugar. Prepare Fehling's solution as follows: I. Dissolve 7 gm. (about ¼ oz.) of crystallized sulphate of copper in 100 ccm. of water and place in a bottle. II. Dissolve 34.6 gm. of crystallized Rochelle salt in 45 ccm. of water, also 25 gm. of caustic soda in 40 ccm. of water. Mix these two solutions, dilute to 100 ccm., and preserve in a bottle properly labeled. Equal portions of solutions I and II are mixed when required for making a test.

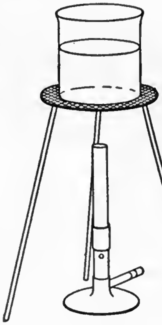

Fig. 2. Tripod and Wire Gauze arranged for boiling Liquids with the Bunsen Burner

Test various food products for sugar by means of Fehling's solution. Honey, sirup, grape juice, or other fruit juices may be used. Dissolve a few drops of these foods in water, heat to boiling in a beaker or other suitable vessel, and add a few drops of the mixed Fehling's solution. A bright red precipitate indicates reducing sugars, such as dextrose, levulose, etc. Cane sugar does not give this test unless it is first boiled with acid.

3. Test for fatty acids. Add a few drops of phenolphthalein[2] to 50 ccm. of alcohol in a small bottle or flask. Add a diluted solution of caustic soda drop by drop until the alcohol is colored red. Introduce a few cubic centimeters of olive oil, butter, lard, or other fat and shake vigorously. If the fat or oil is at all rancid, the red color

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[1] The method of preparing this and other reagents will be found in the Appendix, page 189.

[2] One tenth gram of the solid dissolved in 100 ccm. of alcohol.

will gradually fade because the alkali is neutralized by the free fatty acids.

4. Test for organic nitrogen. Introduce a small portion of dry meat, wheat flour, white of egg, or other nitrogenous food into a test tube. Add a piece of metallic sodium[1] or magnesium about the size of a pea. Heat to redness in the flame of a Bunsen burner. When cool dissolve the contents of the test tube in water and add a few drops of solutions of ferric chloride and ferrous sulphate and then add hydrochloric acid until the solution is acid. A deep blue color indicates the presence of nitrogen in the food tested.

5. Test for mineral matter. Place several grams of flour, potato, or other food in its natural state in a platinum or porcelain dish and heat over a Bunsen burner until the food begins to burn. The black color is evidence of the presence of carbon. Continue the heating until only a white residue remains. This is the ash of the food and contains the mineral matter of the food. Add a little water and warm and moisten a piece of red litmus paper with the solution. A blue color indicates the presence of sodium or potassium carbonate or other salts, which are generally present in considerable quantities in vegetables. The ash may also be tested for magnesium, calcium, iron, and aluminum, which are usually present in vegetables.

6. Digestion of protein. To 9 ccm. of dilute hydrochloric acid add 291 ccm. of distilled water. Dissolve $\frac{1}{10}$ gm. of pepsin in 150 ccm. of the diluted acid. Boil a fresh egg for fifteen minutes. Remove the white, press it through a fine sieve, and place 10 gm. in a bottle of suitable size. Add 35 ccm. of the diluted acid and rub the albumen fine with a glass rod. Add 5 ccm. of the pepsin solution. Cork the bottle and place in water kept at 52° C. (126° F.). Allow to remain for several hours, shaking occasionally. The albumen has now been converted into peptone, as may be shown by the following tests. Boil a portion of the solution and to another portion add zinc sulphate. Repeat these tests with a solution of the uncooked white of egg in water and observe the difference. Peptone may be precipitated by the addition of a solution of tannin.

7. Test for solids and mineral matter of milk. Place 10 ccm. of milk in a porcelain dish. Evaporate to dryness on the water bath. Only the water passes off during the evaporation. The residue

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[1] Metallic sodium must not be allowed to come into contact with water, as it may explode. It should be kept under kerosene.

constitutes the solids of the milk, which give it its food value. Heat the dish with the Bunsen burner until the milk solids begin to burn. If the operation were carried out in a calorimeter so that the heat produced would pass into the water, the calorific value of the milk would be obtained. Continue the heating until the solids are completely burned and only a nearly white ash remains. This ash may be tested as directed in the preceding experiment.

CHAPTER II

WHAT IS PURE FOOD?

Pure food. The term "pure food" can be defined only after long experience with all kinds of foods and very exhaustive scientific and practical investigation. While much work of this kind has been completed, many investigations are being carried on at the present time in order to determine which foods are pure and which are impure. Food producers and manufacturers have by no means arrived at fixed standards of excellence for their products. Many new foods are being constantly placed on the market, in regard to which no reliable opinion can be given until they have been thoroughly tested. From the consumer's standpoint there is such a great difference in individual constitution and condition that what is perfectly harmless and even beneficial to one man may be poisonous to another. Our present definitions of a pure food must therefore be tentative and subject to change, as time goes on, to meet the requirements of experience, scientific investigation, and the changing conditions of our food supply and manufacture. Many foods must be classed as pure, even though they are injurious to some people.

Adulterated foods. In general it must, of course, be assumed that a pure food is one which, properly consumed, will nourish a healthy human being without producing distress of any kind, sickness, or death. The definition of a pure food indicates the method of differentiating between foods possessing these qualities and injurious ones. Foods are also classed as adulterated if the purchaser is deceived as to their natural origin or constituents, or if they are below standard in nutritive value. Such standards are fixed by law, and an otherwise pure and wholesome food which does not conform to such standards is classed as adulterated. The following essentials of a pure food have been embodied in most legal definitions.

Long-used foods, pure. In the first place, a food is pure if it has been in common use for a long time. While such a food may be injurious under certain circumstances, and indeed frequently is, it is not called impure because its peculiarities are a matter of common knowledge. There is no deception or fraud involved in the sale of such an article. If a person is injured by eating it, it is held to be his own fault in that he is ignorant of its properties. For example, many people have died from the excessive consumption of pickles and vinegar. Excessive quantities of salt are injurious, so that the eating of much salt meat leads to serious disorders. Although sugar is one of the best foods we have, its excessive consumption is injurious. No one would think of calling these well-known foods impure. Any attempt to restrict their sale or consumption would certainly fail.

Substitution. The attitude of the public toward a new food product is entirely different. If it can be shown to be injurious toward even a very small proportion of those who eat it, it is apt to be declared unwholesome. This is mainly due to the fact that the public have not learned by long experience just what the circumstances are under which it is injurious. Opposition to a new food is especially violent when it is sold under the name of a common, long-used food or mixed with such a food product. Such a practice constitutes a moral as well as a legal fraud. A food sold in this manner is called an impure or adulterated food, even though it may be entirely harmless and nutritious. It is being generally recognized that such a practice is poor policy from a business standpoint. Many examples of this kind of adulteration may be cited. Cottonseed oil has been largely sold as olive oil. A large number of the sirups on the market are composed in large part of glucose. The best California wines have been sent to France, placed in bottles bearing the labels of well-known French brands of wine, and returned to this country. The inferior California wines have been sold under their own names. The California wine grower now finds that his product has a bad reputation, even though he produces wine equal to any grown in France. In the same manner, glucose, although an excellent food product, is generally considered injurious simply because it has always been sold fraudulently, and the public has not had the opportunity to use it knowingly and learn its merits. Many people have long used cottonseed oil under the name of olive oil and prefer it to the real article, but not under the name cottonseed oil.

Poisonous constituents. Every food is, of course, considered impure and adulterated if it contains constituents which may correctly be classed as poisonous, such as arsenic, lead, copper, etc. A number of chemical compounds have been used as preservatives which are certainly poisonous, while a few preservatives have been discovered which do not seem to have any deleterious influence on the human system when consumed in small quantities. The same statement can be made of the aniline dyes. Some of these brilliant coal-tar colors are highly poisonous, while others have been fed to animals in large quantities and even injected directly into the blood without any ill effect. No ill effect has been observed when these dyes have been consumed in large quantities by human beings. Foods which have been derived from diseased or decayed plants or animals are classed as impure or adulterated. Such foods may contain the germs of disease as well as many poisonous substances which are known to be produced during diseases or in the process of decay. Even if such foods do not contain any poisonous constituents, everybody has such a strong natural aversion to diseased or decayed matter that the sale of such food is violently resented by the public. That partially decayed food is not necessarily injurious is evident from the large consumption of the so-called fermented cheese and tainted venison and other meat.

Reduction of food value. In addition to the requirement that pure foods shall contain none of the classes of poisonous ingredients already named, a pure food is defined as one from which none of the nutritious constituents have been withdrawn or the food value lowered in any manner. For instance, milk from which the cream has been removed is classed as adulterated unless it is sold as skim milk. The addition of water is also a fraud.

Deception. Pure food must not be coated, colored, or painted so as to appear better than it really is. For instance, milk is sometimes colored to make a poor product appear richer in cream. Cheap candies are often coated with shellac varnish so as to imitate the appearance of chocolate, which they really do not contain. Both of these practices are condemned as fraudulent. The same is true of the addition of coloring matter to butter; while this practice is illegal, it is not suppressed because most people prefer yellow butter, and no fraud is involved unless oleomargarine is colored to imitate butter and is sold as such.

Misleading labels. By legal enactment in many states, a food to be classed as pure must be sold under a name or label which correctly gives its composition or the place or firm by whom it is produced. To prove that there was nothing injurious in its composition would not save a merchant from prosecution for selling a food under a misleading label. The sale would be fraudulent because the purchaser would be getting something different from what he supposed he was getting for his money.

Legal standards. In general, a food to be called pure must conform in every particular to the law. In some cases the words "pure" and "impure" or "adulterated" acquire a very unusual meaning by legal enactment. For instance, the laws of many states specify that milk must contain 12 per cent of solids. Some cows give milk containing a smaller proportion of solids. The sale of such milk is illegal, even if it is shown to have been sold in absolutely the same condition in which it came from the cow. This is an example of an absolutely pure natural product declared by law to be impure and adulterated. Of course the standard fixed by law is slightly lower than the average composition of pure cow's milk.

Adulterated food. Food is impure or adulterated, therefore, when it contains injurious constituents of any kind, when it is below the standard in food value, when sold under some form of fraud or deception, or when it does not conform in some respect to pure-food laws. The words "impure" and "adulterated" as applied to foods very rarely imply the presence of what are commonly considered poisonous constituents.

CHAPTER III

STANDARD RATIONS AND THE COST OF FOOD

The daily ration. If the amount of the various kinds of food consumed during twenty-four hours by a human being under normal conditions is weighed, and the total amount of each of the food constituents is calculated, the result gives what is known as the daily ration. For a given age or condition of life this is found to be surprisingly constant, not only with respect to the total amount of food taken, but also with reference to the relative amounts of fats, carbohydrates, and protein. The total calorific power which represents the energy which the system can obtain from the food is also very constant.

A balanced diet. If the amount and kind of food is not well selected, an excess of one or more of the essential constituents of food will be present and must be eliminated to the detriment of the system. For instance, a diet composed largely of meat will contain more protein matter than is required to keep the tissues in good condition. It is necessary with such a diet to consume this excess of protein matter in order to obtain the proper amount of fats and carbohydrates. Such a diet is not well balanced.

The standard ration gives the quantities of fats, carbohydrates, and protein found to be just sufficient to sustain a human being under given conditions in normal health and activity.

The standard ration. The daily ration found by most investigators contains 100 gm. of protein, 100 gm. of fat, and 420 gm. of carbohydrates, or a total of 620 gm. These weights refer to the solid matter only of the food. In its ordinary condition about three times this amount would be required because ordinary food contains a large amount of water. Expressed in ordinary or avoirdupois weights, this standard ration would require 3½ oz. of protein, 3½ oz. of fat, and 15 oz. of carbohydrates, or a total of 22 oz. of solid food, which is equivalent to about 4 pounds of ordinary food. The 3000 calories of energy given by this amount of food, if liberated as heat, are capable of raising 10 gallons of water from the ordinary temperature to the boiling point; if used as mechanical energy, 2000 pounds, or one ton, could be raised 4500 feet, or very nearly a mile. It seems well-nigh incredible that the food consumed by the average human being during twenty-four hours should liberate so much energy.

Interchangeable foods. While a great many of the tissues of the body can be built up and repaired only by protein, which for this reason is of the greatest importance in the diet, this food material can also furnish energy and therefore serves a double function in the economy of nature. It can therefore replace to a certain extent fats and carbohydrates in the diet. To a still greater extent, fats and carbohydrates are mutually interchangeable. It is therefore possible to live on a diet in which the proportion of the food constituents is very different from that in the standard or normal ration. There seems also to be a very great difference in individuals, so that considerable variation is often necessary in order to suit idiosyncrasies of appetite, digestion, and assimilation. The consumption of excessive quantities of protein seems to be undesirable.

Rations for children. During periods of unusual activity a much larger amount of food is consumed, while the aged and children consume less. The ration for children is given in Table II. It will be observed that the amount of protein in the diet of the child is relatively larger than in that for the adult. The child one year and a half old requires 24 per cent of its food to be protein, while the adult requires only 16 per cent. The child is building up a new body structure, while the adult is simply making repairs.

TABLE II

RATIONS FOR CHILDREN

Age	Protein	Fat	Carbohydrates	Calories
	Grams	*Grams*	*Grams*	
1½ years	42.5	35	100	910
2 years	45.5	36	110	972
3 years	50	38	120	1050
4 years	53	41.5	135	1157
5 years	56	43	145	1224
8–9 years . . .	60	44	150	1270
12–13 years . . .	72	47	245	1737
14–15 years . . .	79	48	170	1877

Special rations. Table III gives a number of special rations which show how trained athletes are capable of utilizing an abnormally large amount of energy derived from food, while the aged cannot utilize as much. As fats and oils produce the largest amount of heat, these foods are consumed in large quantity by the inhabitants of the coldest climates of the earth, while they are avoided by those living in the torrid zone. Men doing a large amount of muscular work also consume fats for the production of energy.

TABLE III

Special Rations

Age or Employment	Protein	Fat	Carbohydrates	Calories
	Grams	*Grams*	*Grams*	
Average adult	100	100	420	3030
Average of seven boat crews	155	177	440	4085
Football team	181	292	577	5740
United States Army	85	280	500	4944
Old man	92	45	332	2149
Old woman	80	49	266	1875

Excessive consumption of protein. A considerable amount of evidence has been brought forth to show that the amount of protein in the ordinary diet is too large. Men in active life and also trained athletes have been fed for long periods on diets containing half the usual amount of protein, remaining vigorous and in good health continually, and in some cases even showing a very marked increase in strength and endurance.[1] While the number of experiments conducted has not been sufficient to prove conclusively that the amount of protein consumed is unnecessarily large, the evidence at hand renders it very probable that we are consuming about twice as much meat and other highly nitrogenous food as is necessary. The stimulating effect of such a diet undoubtedly accounts for the tendency of mankind for centuries to consume large quantities of meat, while only recently has scientific investigation begun to show that the carbohydrates and fats of our diet give the greater endurance and strength.

Coefficient of digestibility. It must be borne in mind when considering dietaries that the food consumed is seldom or

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[1] See Chittenden, The Nutrition of Man.

never completely digested, although the percentage so utilized by the system is in many cases surprisingly large, as may be observed from an inspection of Table IV.

TABLE IV

Coefficient of Digestibility of Nutrients in Foods

Food	Protein	Fats	Carbohydrates
	Per cent	*Per cent*	*Per cent*
Bananas	85	90	90
Beans	80	98	97
Beef	98	98	
Bread, white	88	90	98
whole wheat	83		95
Milk and butter	97	95	98
Peas	83		95
Pork	98	98	
Potatoes, Irish	75		99
Sugar			98
Average common foods	91	95	98

The percentages given in this table do not show the ease with which these foods are digested. They simply give the proportion of the food which is finally digested, whether the effort on the part of the digestive system is great or small. It is also assumed that the food is properly masticated and that excessive amounts are not consumed. It may be stated, in general, that the protein matter of vegetables is not as digestible as that of meats.

The method of calculating the daily ration from a mixed diet is shown in Table V.

A record of the amount of each article of food consumed during a week was kept and the weight of each of the constituents calculated from the percentage composition of the food, and also the total calorific value. Allowance

TABLE V

Week's Food for Four Adults

Food	Pounds	Protein	Fats	Carbohydrates	Calories	Cost
		Grams	*Grams*	*Grams*		*Cents*
Sugar	10½			4,756	19,500	54
Prunes	2	17.2		564	2,378	22
Corn flakes	1	40	10	340	1,655	20
Fish	4¼	231	77		1,650	54
Butter	3	13.5	1,155		10,512	87
Lima beans	1	33.3	2.7	131.2	467	7
Malt	1	50	5	338	1,645	13
Uneedas	½	22	12	150	800	5
Lettuce	¾	7	1.2	17	110	16
Eggs	1½	100	80		1,190	25
Blackberries	3	21	15	132	780	54
Beef	2	172	64.4		1,300	32
Condensed milk	¾	22	28	70	600	10
Milk	14	460	560	696	10,000	113
Onions	½	3	.8	20	210	7
Strawberries	2	14	10	88	520	36
Cauliflower	¾	3	.8	20	210	15
Potatoes	6	48	24	414	1,950	24
Bread	3	129.3	132	718.5	3,615	15
Pretzels	1	44	24	300	1,600	5
Leg of lamb	4	270	270		3,620	64
Oatmeal	2	140	66	616	3,720	10
Herring	1	115	38		825	17
Flour	9	460	45	3,042	14,805	27
TOTAL PER WEEK	74½	2,418	2,599	12,412	84,662	731
TOTAL PER DAY	$10\frac{9}{14}$	345	371	1,773	12,095	104
FOR ONE ADULT	2⅝	86	93	443	3,024	26
STANDARD RATION		100	100	420	3,030	

must be made in preparing such a table for unconsumed portions and the necessary waste in preparing food for the table. From the total of each column the amount per day for each individual can be calculated. The daily ration in this case was 86 gm. of protein, 93 gm. of fats, 443 gm. of carbohydrates, and 3024 calories, which is very nearly identical with the standard ration, although a little low in protein.

Comparative cost of foods. It is evident that a given food constituent, such as protein, can be obtained from a large variety of foods. On account of the difficulty of producing a given food, its scarcity, or a very desirable flavor, the cost of the same amount of protein may vary within very wide limits. In order to show the great difference in the cost of foods, Table VI has been prepared. The cost of a sufficient amount of each food to give 3000 calories has been

TABLE VI

COST OF A DAILY RATION OF A SINGLE FOOD

Food	Price	Cost of 3000 calories
	Cents	*Cents*
Flour	3½ per pound	6.3
Oatmeal	5 per pound	8
Rice	8 per pound	15
Sugar	5 per pound	8
Beef	20 per pound	58
Milk	9 per quart	38
Eggs	40 per dozen	184
Cheese	18 per pound	26
Fish	14 per pound	101
Potatoes	80 per bushel	12
Cauliflower	15 per pound	215
Onions	14 per pound	215
Strawberries	13 per pound	250
Butter	35 per pound	29
Olive oil	250 per gallon	23
Bananas	15 per dozen	40
Oysters	12 per dozen	553

calculated. As this is the amount needed during twenty-four hours by the average adult, the figures given show the cost of a day's ration of each article of food.

While living on a single article of food for even one day would not be very desirable, and would be actually done only under very unusual conditions, the calculation of the cost of such a day's ration shows very clearly the comparative cost of the various articles of food. A study of this list shows that the price per pound gives very little idea of the comparative economy of buying a given food. Beef, for instance, at 20 cents a pound is a very much cheaper food than fish at 14 cents per pound, since, when buying beef, 58 cents will buy as much nutritive value as $1.01 will purchase when buying fish. The cheapest articles of food cannot always be purchased, however, because the proper balance between the fats, carbohydrates, and protein must be maintained, and some foods must be used on account of their beneficial effect on the digestive system.

The following table shows how the same nutritive value as well as the correct proportion of the various food constituents can be obtained at a very great difference in cost.

TABLE VII

Cost of a Day's Food of Beefsteak, Potatoes, and Butter

Food	Cost	Protein	Fat	Carbohydrates	Mineral matter	Calories
	Cents	*Grams*	*Grams*	*Grams*	*Grams*	
Steak, 1⅓ lb. . .	30	87	52		4	937
Potatoes, 5 lb. . .	8	40		339	20	1630
Butter, 2 oz. . .	5		48			450
Total	43	127	100	339	24	3017

TABLE VII (Continued)

Cost of a Day's Food of Eggs, Bread, and Butter

Food	Cost	Protein	Fat	Carbohydrates	Mineral matter	Calories
	Cents	*Grams*	*Grams*	*Grams*	*Grams*	
Eggs, ¾ doz. . .	38	66	52		5	838
Bread, 1⅜ loaves .	6	48	4.5	325	9	1650
Butter, 2 oz. . .	5		48			450
Total	49	114	104.5	325	14	2938

Cost of a Day's Food of Fish, Potatoes, Butter, and Olive Oil

Food	Cost	Protein	Fat	Carbohydrates	Mineral matter	Calories
	Cents	*Grams*	*Grams*	*Grams*	*Grams*	
Bluefish, 2 lb. . .	40	86	5		4.7	410
Potatoes, 4⅘ lb. .	8	39		328	17.8	1575
Butter, 2 oz. . .	5		48			450
Olive oil, 2 oz. .	5		54			528
Total	58	125	107	328	22.5	2963

Cost of a Day's Food of Oysters, Bread, Butter, and Olive Oil

Food	Cost	Protein	Fat	Carbohydrates	Mineral matter	Calories
	Cents	*Grams*	*Grams*	*Grams*	*Grams*	
Oysters, 2½ lb. . .	107	65	9.1	35.8	6.5	575
Bread, 1⅕ loaves .	6	42	3.9	284.5	7.8	1440
Butter, 2 oz. . .	5		48			450
Olive oil, 2 oz. .	5		54			528
Total	123	107	115	320.3	14.3	2993

TABLE VII (CONCLUDED)

COST OF A DAY'S FOOD OF MILK, BREAD, AND BUTTER

Food	Cost	Protein	Fat	Carbohydrates	Mineral matter	Calories
	Cents	*Grams*	*Grams*	*Grams*	*Grams*	
Milk, 2¼ qt.	18	73	69	88	13.4	1430
Bread, 1⅛ loaves .	6	40	3.7	267	7	1350
Butter, 1 oz. . .	2		30			225
TOTAL	26	113	102.7	355	20.4	3005

CHAPTER IV

MILK

Importance of milk as a food. Milk is one of the most largely used of human foods. The city of New York uses 2,000,000 quarts of milk per day; 500,000 gallons come pouring into the city every twenty-four hours, and are consumed by the population. If this amount of milk were divided equally, every person would have one-half quart of milk per day. This amount is sufficient to constitute 10 per cent of the standard daily ration, and when we consider that not over half of the population of the city is consuming the standard daily ration, because that is the ration for an adult in vigorous, active life, it is evident that milk constitutes a much larger percentage of the food consumed by the people of New York. It is of still more importance because it is almost the entire food of young children, and is a large part of the diet of the child up to ten years of age, and frequently beyond. In addition, it is the chief source of nourishment of invalids and the aged, — in fact, of any person whose state of health is such that he needs an easily digested, highly nutritious food. Without it a large number of the sick and invalid would undoubtedly perish. It is probably true that an adulterated and improperly handled milk supply will produce more suffering, sickness, and death than has resulted from the adulteration of all other foods combined. There is no other food product the condition of which produces such a marked effect on the death rate of a community. The great reduction in the death rate of young children in American cities during recent years is well known to be due to the great advance made in our knowledge of the composition and methods of transportation and preservation of milk.

Constituents of milk. Among common foods milk probably approaches nearest the ideal food. It contains all the important constituents of a complete food, — protein, fats, carbohydrates, and mineral matter. When milk is allowed to stand quietly for some time, the fat rises to the top and is removed in the form of cream, from which the fat is separated in a still purer form as butter. When the skim milk sours, the protein, known as casein, separates as curd. The various kinds of cheese contain nearly all of the protein of the milk as well as more or less of the fat. When the curd has been removed, there remains a somewhat sweetish liquid known as whey. This contains the sugar and mineral matter of the milk. By boiling the whey until a great deal of the water has been expelled, and inserting strings or sticks of wood, the sugar crystallizes out and is broken up or powdered, to be sold as milk sugar. The remaining liquid contains most of the mineral matter. By boiling until the water is entirely volatilized a solid remains, which can be heated to redness without being entirely burned up. This residue, which is incombustible, is the mineral matter or ash of the milk. Cow's milk, which is the milk most largely used, varies considerably in composition, depending on the season, breed, age, method of feeding, etc., of the animal. The composition of the milk of a mixed herd is much more constant, the figures given in Table VIII referring to such milk.

The largest constituent is water. The solid constituents are not present in the proportion given for the standard adult ration, the protein being present in much larger proportion, so that it approaches more nearly the ration given for children, who need more protein for the growing tissues. When milk is used as a food for the adult, sugar or some starchy food such as bread should be eaten with it. In protein cow's milk is much richer than human milk, while human milk is much richer in sugar.

TABLE VIII

Composition of Milk

Constituents	Cow's milk	Human milk
Calories	325	
	Per cent	*Per cent*
Water	87.3	87.4
Total solids	12.7	12.6
Fat	3.6	3.78
Protein	3.8	2.29
Milk sugar	4.5	6.21
Lactic acid	.1	
Ash	.7	.31

Ratio of Constituents of Cow's Milk

Protein 100 : Fat 100 : Carbohydrates 125

Modified milk. It is evident that if cow's milk is to be modified, so as to be used for infants, the amount of protein must be reduced. This is done by diluting the milk to a considerable extent. This reduces the fat and the sugar. These two constituents must then be increased by adding cream and milk sugar; so that in adapting cow's milk to the feeding of infants it is diluted and then enriched with cream and milk sugar, and made to correspond very closely to human milk, the natural food for the child.

High protein content. Milk must be classed as a high protein food. The amount of protein given in Table VIII, 3.8 per cent, seems very small, but account must be taken of the fact that there is present in the milk but 12.7 per cent of solids, so that nearly one third of this solid matter is protein. Meats and fish are the only foods which exceed milk in the amount of protein present. Two and a half quarts of milk contain as much protein matter as a pound of meat, and in addition the milk contains sugar and fat. As a food two and a half quarts of milk are worth a great deal more than a pound of meat. If one could live on milk alone, less than four quarts a day would suffice, and at 8 cents per quart, it would cost 32 cents per day. Compared with other high protein foods, this is a very low cost, as may be seen from an inspection of Table VI. From the following table it may be seen that milk alone is a poorly balanced food, with an excess of protein, but that the addition of bread and butter improves the ration and also reduces the cost.

TABLE IX

DAILY RATION OF MILK

	Cost	Protein	Fats	Carbo-hydrates	Ash	Calories
	Cents	*Grams*	*Grams*	*Grams*	*Grams*	
4 quarts	32	133	126	157	24	2920

DAILY RATION OF BREAD, BUTTER, AND MILK

Milk, 2 qt. . . .	16	66	63	78	12	1460
Bread, 1⅛ loaves .	6	50	5	257	5	1355
Butter, 1 oz . . .	2		30			225
TOTAL	24	116	98	335	17	3040

A staple food. Milk is classed as a "staple food," because it is one which can be consumed continually by a very large number of human beings without detriment or particular dislike. Only when the adult has been compelled to live on milk exclusively for a considerable period does he absolutely lose his desire for and enjoyment of milk.

Variations in composition of milk. The figures given represent the average composition of milk. The natural variations are quite large. The total solids may vary from 9 to 17 per cent; that is, one milk may be nearly twice as rich as another, the corresponding amounts of water being 91 and 83 per cent. The fat may vary from 1.67 to 6.4 per cent, the milk sugar from 2 to 6 per cent, the protein from 2 to over 6 per cent, and the ash from .35 to 1.2 per cent. On account of these large variations in the composition of milk, consumers would be defrauded unless its sale were regulated by law. A minimum of 12 to 13 per cent of total solids and 3 to 3½ per cent of fat is usually required. If the milk contains less than these amounts, for whatever cause, it is considered adulterated, so that its sale is illegal.

Variations in New York City milk. The following table shows the variation in percentage of fat in milk sold in New York City:

TABLE X

PERCENTAGE OF FAT IN MILK SOLD IN NEW YORK CITY

		Per cent	*Per cent*	*Per cent*
Milk Co. No. 1	8¢, bottled	3.8		
Milk Co. No. 2	8¢, bottled	3.8	3.8	3.6
Milk Co. No. 3	8¢, bottled	3.4	3.6	3.5
Milk Co. No. 3	15¢, bottled (certified)		4.8	
Milk Co. No. 4	8¢, bottled		3.3	
Milk Co. No. 5	8¢, bottled		3	2.5
	6¢, in cans	3.2	3.2	3.1

The fat varies much more than the other constituents of milk, the protein, milk sugar, and ash remaining quite constant. The variation in the milk of Dairy Company

No. 2 occurred within a few days. The milk of Dairy Company No. 5, containing only 2.5 per cent fat, was below the legal standard, and whether it was watered or whether the cows produced such very thin milk, still its sale was illegal, and the company selling it was subject to a fine. The 6-cent milk is low in fat also, but just above the legal standard.

Cream. The fat of milk is removed and sold separately as cream. It may be separated from the milk in two ways, — either by allowing it to rise and skimming it from the top of the milk, or by means of mechanical separators, which separate the fat very completely from the fresh whole milk. We have, then, two kinds of cream, the "separator" cream and the "light" cream. The following table shows their composition:

TABLE XI

	Fat	Other solids	Water
	Per cent	*Per cent*	*Per cent*
Separator cream . .	38–46 (av. 42)	6.3	51.7
Light cream . . .	8.6–21.6 (av. 13.9)	8.25	77.85

Comparative cost. The comparative cost of milk, cream, and butter, based on the calorific values, is given in the following table:

TABLE XII

COMPARATIVE COST OF MILK, CREAM, AND BUTTER

	Cost	Calories	Cost of 1000 calories
	Cents		*Cents*
Cream, ½ pt.	12	1044	11.49
Milk, 1 qt.	8	730	10.96
Butter, 1 lb.	35	3605	9.71

Thus we find that cream is the most expensive food of this kind that we can buy, milk is the next, and butter is the cheapest.

Skim milk. After the cream has been separated, there remains skim milk, which contains nearly the same amount of protein, milk sugar, and ash as the sweet milk, while only a trace of fat remains. In New York and other cities it is illegal to sell skim milk. This is unfortunate, because skim milk is an excellent food. It lacks, of course, the fat, but contains protein, carbohydrates, and ash, which make it a valuable food which could be sold at a fairly low price. The danger is that it would be sold as whole milk, so that the public would be deceived. If the golden rule were observed and every one were honest, unquestionably we should get along better. If every one would sell skim milk as skim milk, its sale would undoubtedly be allowed, and this cheap food product would be available. It is sold, however, but not as skim milk. Most of it is sold as buttermilk. The buttermilk is prepared by adding to the sweet skim milk a pure culture of the bacteria which produce lactic acid, and as these bacteria grow the milk curdles. Some sweet whole milk is usually added and the mixture churned in order to obtain a product resembling the buttermilk obtained in the creameries.

Evaporated milk. The skim milk is also evaporated and reduced to a powder, which is known as evaporated milk. It contains all the solids of the skim milk, the water only having evaporated. It is being used more and more by the wholesale food houses, who mix it with flour in preparing the special self-raising flours which are used for making pancakes and similar foods. It is more convenient to have the milk in this form mixed with the flour, and is probably somewhat cheaper than using fresh milk.

Casein. The casein is also separated from the milk and powdered, so that it may be added to other foods, in order to increase the proportion of protein. A less pure casein is used for other purposes. A cold-water paint is made from such casein. Casein will dissolve in water, and, if spread out like paint, the solution will dry and form a hard film. By mixing pigments with it, paints of various colors are obtained that will dissolve in water. Where a surface is not exposed to dampness, this water paint is quickly applied and is convenient.

EXPERIMENTS

8. Constituents of milk. Place about 25 ccm. of milk in a porcelain evaporating dish and heat on the water bath until dry. The residue consists of the fat, casein, sugar, and mineral matter of the milk. Add a few cubic centimeters of ether and stir the solid residue with a glass rod so as to dissolve the fat. Pour the clear ether solution on a watch crystal and allow the ether to evaporate. The residue is the butter fat of the milk. By repeating the extraction with ether all of the fat may be removed from the milk residue.

9. Casein and milk sugar. Heat about 200 ccm. of skim milk to 90° F. and add a few drops of rennet or a few cubic centimeters of acetic acid, and allow to stand in a warm place until the milk is curdled. The curd is the casein or protein of the milk, and may be separated from the whey by filtering through cheesecloth. Make the whey slightly alkaline by adding limewater and testing with red litmus paper until the paper has turned blue. Evaporate to about half the bulk, or until the albumen has been precipitated.

Filter and again evaporate to about one sixth the bulk. Cool, add an equal volume of methyl or wood alcohol, and allow to stand for several hours or until a crystalline precipitate is formed. This is milk sugar. Filter it off and dry.

10. Test for borax. Test the milk for borax or boric acid in the following manner: 25 ccm. of milk is placed in a porcelain dish, a little limewater added, and the whole evaporated to dryness. Heat the dish to redness with the Bunsen burner. The milk residue decomposes and burns. On continued heating, the charcoal burns and leaves a white residue. This is the ash or mineral matter in the milk, plus the lime which was added. If borax or boric acid had been added to the milk as a preservative, it would be present in this residue.

The preservative may be tested for as follows: Dissolve the residue in a few drops of hydrochloric acid and moisten a strip of turmeric paper in the solution. Dry the paper, being careful not to heat it above 100° C. The development of a bright red color indicates the presence of borax or boric acid. The red color is changed to a dark green by a drop of ammonia. If a large amount of preservative is present, the milk may be tested directly after adding a few drops of hydrochloric acid.

The test may also be carried out in the following simple manner: Acidify the milk with a few drops of hydrochloric acid and hang a strip of turmeric paper so that the lower edge is moistened with the milk. After six or eight hours a cherry-red color will appear at the border of the moist portion if boric acid is present.

In order to become familiar with the delicacy of the test, dissolve 1 gm. of borax in 100 ccm. of pure milk. Dilute this solution by adding 10 ccm. to 90 ccm. of pure milk. Repeat the dilution, using 10 ccm. of the last solution and 90 ccm. of pure milk. In this manner samples of milk will be obtained having 1 part of borax in 100, 1000, and 10,000 parts of milk. Test these samples of milk in the manner indicated and observe the delicacy of the test. Also allow the milk to stand several days in order to observe the preservative action.

11. Test for formaldehyde. Test milk for formaldehyde in the following manner: Place 10 ccm. of the milk in a test tube and pour carefully down the side of the inclined tube 5 ccm. of concentrated commercial sulphuric or pure sulphuric acid to which a little ferric chloride has been added. A violet coloration is produced at the junction of the two liquids if formaldehyde is present.

Also make the test in the following manner: 15 ccm. of the milk is placed in a small casserole or other suitable dish. Add an equal volume of commercial hydrochloric acid or pure acid to which a little ferric chloride has been added. The mixture is slowly heated to the boiling point. It is continually stirred or agitated to avoid charring, as well as the formation of curd. A violet coloration is produced if formaldehyde is present. In this experiment as well as in the test for borax it is very important that the test be carried out by the beginner on samples of milk containing known quantities of the preservative. Samples of milk containing 1 part of formaldehyde in 1000, 10,000, and 50,000 should be prepared. For this purpose the commercial 40 per cent formaldehyde solution may be used. 5 ccm. is diluted with water to 20 ccm., and 1 ccm. of this solution is added to 99 ccm. of pure milk. On diluting 10 ccm. of this milk with 90 ccm. of pure milk, and again diluting 20 ccm. with 80 ccm. of pure milk, samples are obtained containing 1 part of formaldehyde in 1000, 10,000, and 50,000 of milk. These samples should be tested and then set aside to observe the keeping qualities.

CHAPTER V

BACTERIA IN MILK

Bacteria. Except under very unusual conditions, milk invariably contains another constituent, namely bacteria. These are minute, microscopic, single-celled organisms, which in a favorable environment flourish and multiply with enormous rapidity. They vary in shape from circular to oval or elongated rodlike bodies. They are capable of more or less motion when in liquids, sometimes having a

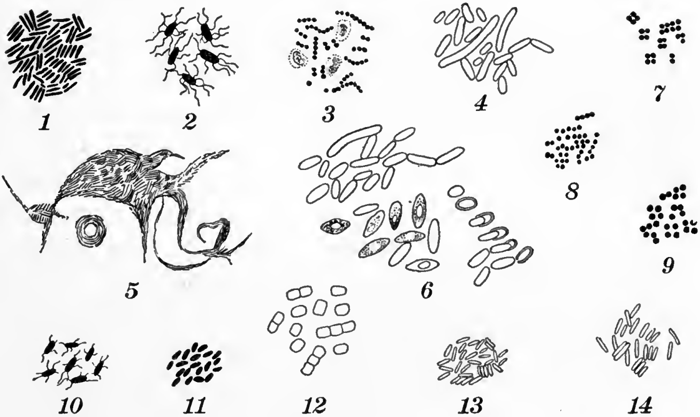

Fig. 3. A Variety of Bacteria likely to be found in Milk[1]

1 and 2, typhoid bacillus (*Pfeiffer*); 3, pus and pus cocci; 4, *B. Dysenterie* (*Shigar*); 5, *Proteus vulgaris*; 6, *Clostridium butyricus*; 7, 9, 10, 11, types of common lactic bacteria (*Conn*); 8, a coccus without influence on milk (*Conn*); 12, 13, 14, three bacilli producing slimy milk (12, *Marshall*; 13 and 14, *Conn*)

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[1] Illustration reproduced from Conn's "Bacteria in Milk and its Products."

number of hairlike flagella which vibrate and propel the bacteria. Although so small that they are visible only through the microscope, they are very important factors in human life. Many of man's most violent and fatal diseases are produced by bacteria. A great many very important chemical transformations are also brought about by these organisms. All of the enormous quantities of alcohol manufactured every year are produced by the yeast ferments. Most of our soils would be arid and unproductive without the activity of bacteria. The various processes of decay are all brought about by their action.

The food of bacteria. These minute organisms are nourished in a manner very similar to that of human beings; that is, the food which they consume is eliminated only after it has been transformed into some other chemical compound. During this transformation the energy necessary for the life of the bacteria is liberated. A given bacterium always transforms its food into a definite chemical compound. It is therefore possible, by selecting the proper bacterium, to transform the starch of any of the grains into alcohol, and on this fact is founded the enormous industries manufacturing fermented alcoholic beverages and pure alcohol. By using another organism the alcohol may be transformed into acetic acid, so that vinegar is produced. Generally the food required by bacteria is some form of organic matter, which must be in solution or at least quite moist. When bacteria which can flourish in the human body and live on such organic matter as is present in the tissues of the body gain entrance, disease usually results because the tissues are being destroyed. Such bacteria are called disease bacteria, such as typhoid, scarlet fever, etc. Most bacteria cannot live under these conditions, but flourish on dead matter outside of living bodies and are therefore quite harmless.

Bacteria flourish in milk. The composition of milk is such that many bacteria flourish and grow very rapidly after gaining entrance. Indeed, few or any other foods offer such favorable conditions for their growth. This is largely because milk is a liquid containing a variety of food material in solution. Bacteria are so widely distributed, being always present in the air, water, dust, and on the surface of all ordinary utensils, that they very rapidly gain entrance to milk, even though considerable care is exercised to exclude them. By exercising the most extraordinary precautions it is possible to draw from healthy cows milk which contains no bacteria, so that they cannot be said to be a natural constituent of cow's milk. As it has not yet been found practicable to draw milk in this manner nor to eliminate the bacteria after milking, it may be said that bacteria are a normal constituent of milk as consumed by human beings.

FIG. 4. Old-Style Barn

Dirty and unsanitary. Particles of dust contain thousands of bacteria

Action of bacteria on milk. It is very important to learn the character of the bacteria which are found in milk, and their effect upon its properties. If they are absolutely excluded, it is found that milk does not become sour, but remains sweet for an indefinite period. The souring of milk is due to the activities of the so-called lactic-acid bacteria. They convert the milk sugar into lactic acid, which causes the milk to curdle and gives it a sour taste. As no other bacteria can grow so rapidly in milk as this organism, they soon far outstrip any others which may have gained entrance, and become the predominating organism. A pint of sour milk would contain about 20,000,000,000 of these minute cells. While such milk is injurious to infants, it can be consumed in large quantities by children and adults without any ill effects, while there is some evidence that at times its use is beneficial. The nutritive value of sour milk is very nearly equal to that of sweet milk.

Tuberculosis transmitted by milk. A great variety of other bacteria are also generally found in ordinary milk. Some of these are present because the cow is diseased. A number of diseases may in this manner be transmitted from cattle to man. This is especially true of tuberculosis, which has become prevalent to an alarming extent in dairy cattle in spite of persistent efforts to check it. Because of the almost equal prevalence of the same disease among human beings, and the slowness with which it develops after entering the human system, it has been found impossible to determine to how great an extent the prevalence of the disease is to be attributed to an infected milk supply. It seems to be well established, however, that the bacteria of this disease may at any time be present in our ordinary supplies of milk and be transmitted to human beings.

Other diseases transmitted by milk. A number of other diseases, such as diphtheria, typhoid, and scarlet fever, as well as dysentery and intestinal diseases, may also be transmitted by means of milk. Measles and smallpox are also believed by many to have been carried by infected milk. The bacteria producing these diseases generally gain entrance to the milk from infected persons who handle it at the dairy or during its transportation to the consumer. The typhoid bacteria may also be introduced from the water used to wash cans or other milking utensils.

Production of pure milk. The requirements, therefore, which must be met in producing and delivering a pure and wholesome supply of milk are the exclusion of disease bacteria and the lessening of the activity of lactic-acid bacteria so that the milk shall reach the consumer before it becomes sour. The great concentration of population around our large cities has very materially increased the difficulties to be overcome by our dairymen. The milk delivered in New York City, for instance, is twenty-four to thirty-six hours old. It must be delivered in such condition that it will remain sweet at least twenty-four hours longer. The

FIG. 5. Model Stalls

Plenty of light, and cement floor kept scrupulously clean production of such a milk supply requires great care at the dairy to prevent the entrance of bacteria. The greatest cleanliness must be observed with reference to the milking rooms, the milking utensils, the cattle, and the dairymen. As dust generally carries bacteria in great numbers, it must be excluded so far as possible. Plenty of light and air must be admitted. In the better class of dairies a veterinary surgeon examines the cattle at frequent intervals to ascertain if they are diseased in any way, and especially in order to make the tuberculin test by which it is possible to ascertain if a cow has contracted tuberculosis in any form. The water used to wash milking utensils is tested to insure its purity. Dairymen having contagious diseases are not allowed to remain at the dairy. To guard against contamination in transit the milk at the dairy is often put in sterilized bottles closed with sterilized caps. Some forty rules of this kind have been compiled by a large milk company for its dairies, and are enforced by an elaborate system of inspectors.

Certified milk. When every precaution of this kind is taken to exclude disease bacteria, and the entire process is supervised by a medical association, the product is called *certified milk* and is sold at a much higher price than ordinary milk. The only test which can be applied to ascertain if a pure product has been produced, is to make a count of the number of bacteria present per cubic centimeter. A limit of about 15,000 is usually established. While there is no absolute certainty that some of the bacteria present may not be those producing disease, experience proves that this is very rarely the case, so that certified milk may be considered by far the purest milk sold. Because of its high cost it is generally used only by invalids and children.

The use of preservatives in milk. A number of methods have been devised for rendering milk, produced under ordinary conditions, safe and capable of remaining sweet for the necessary length of time. A number of chemical compounds, known as preservatives, have been found which will prevent milk from souring if added in very minute quantities. As this method has commonly been condemned by health authorities, it has not come into general use. In most cities dealers selling such milk are subject to a heavy fine.

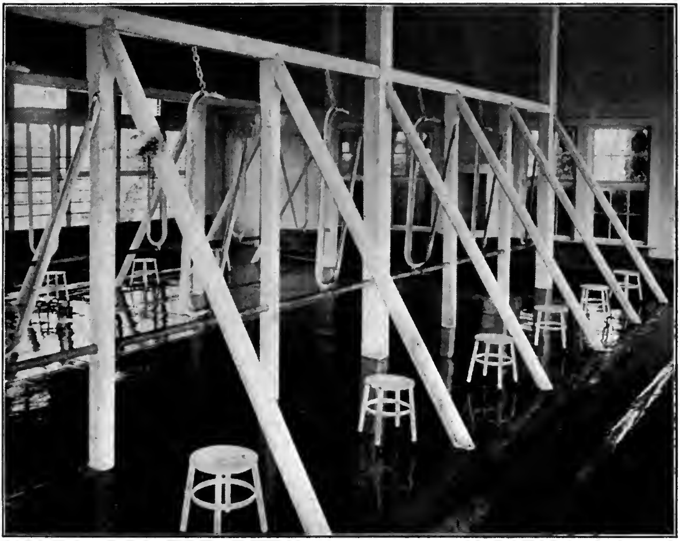

FIG. 6. Model Milking Room

Sterilized milk. Heating the milk to a sufficiently high temperature has been found to kill the bacteria. If the milk is heated to a temperature considerably above its boiling point, absolutely all bacteria are killed; and if properly protected from the entrance of bacteria, such milk will remain sweet indefinitely. It is then known as sterilized milk. It is not, however, a suitable food for invalids and children, the high temperature having materially changed its properties.

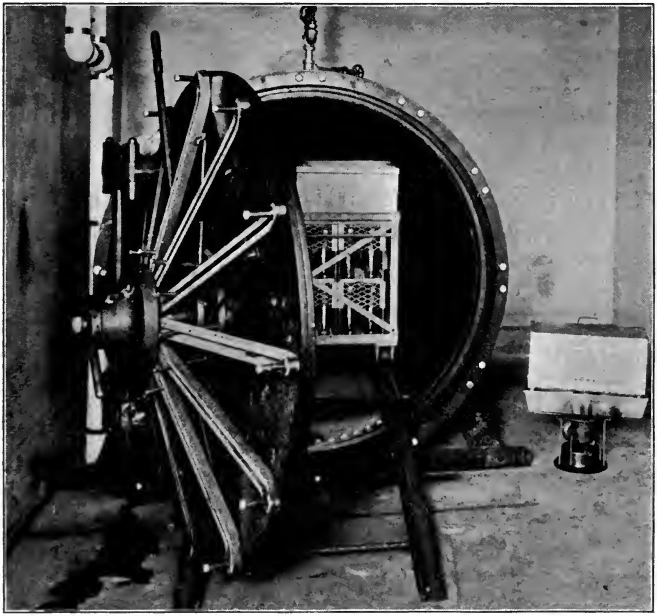

FIG. 7. Steam Sterilizer

The milk bottles are loaded on small cars which are run into the sterilizer, the door bolted on, and steam introduced

Pasteurized milk. It has been found that the various species of bacteria are not equally susceptible to the influence of heat, so that some are killed at a much lower temperature than is necessary for others. This difference is largely due to the fact that some species of bacteria are capable of producing spores which are analogous to the seeds of plants and can resist drought and heat to a considerable extent. Under favorable conditions of temperature and moisture these spores are capable of developing into bacteria actively growing and multiplying. As the disease-producing bacteria which occur in milk do not produce spores, they are destroyed at a relatively low temperature. This fact was discovered by the great bacteriologist Pasteur. His name is therefore given to the process of heating milk to a temperature just sufficient to destroy these bacteria. This is accomplished by heating the milk for twenty minutes at 165° F. or 65° C. Such milk is called Pasteurized. It still contains a small number of living bacteria or their spores, which develop and multiply if the milk is allowed to stand at room temperature for a day or two. It will remain sweet for a much longer time than the unheated milk, and is a perfectly safe article of diet

Fig. 8. Filling Milk Bottles

Milk reservoir is covered to keep out dust, and bottles are capped immediately because the disease bacteria which may have been present have been killed. Some of the constituents have undergone slight changes in composition, as is evident from the taste which is not identical with that of the unheated milk. In this respect certified milk is to be preferred.

Advantage of Pasteurization. Pasteurization is the only method of treating milk to render it safe as a food, which has been found commercially feasible. The increased keeping qualities of the Pasteurized milk compensates for the slight expense of heating it. Both the dairy and domestic Pasteurization of milk has been very extensively employed in recent years, so that a large proportion of the milk sold in our large cities is now Pasteurized. The commercial Pasteurization of milk often differs from the scientific method of carrying out this process in that the milk is kept hot for a much shorter time than twenty minutes. While the vitality and virulence of disease bacteria are undoubtedly very much reduced by such a process, it is certain that they are not killed. Fortunately the normal healthy human being is able to destroy great numbers of disease bacteria, but for invalids and very young children it is advisable to Pasteurize for twenty minutes.

Buddeized milk has been considerably used in Europe. This process is somewhat similar to Pasteurization, but differs in that the temperature employed is somewhat lower than 50° C. or 122° F., and that in addition a small amount of hydrogen peroxide is added. This compound is similar to water, but differs in that it contains more oxygen. It is an excellent disinfectant, and when acting as such it decomposes into oxygen and water, leaving no other decomposition product. During the Buddeizing process all the hydrogen peroxide added is decomposed, while the bacteria are destroyed quite as completely as during the Pasteurization.

Variations in the bacteria content of milk. The following table gives the number of bacteria found in milk as sold in New York City:

TABLE XIII

Bacteria in Milk sold in New York City

		Number per cubic centimeter			
Milk Co. No. 1 . .	8¢, bottled	342,000			
Milk Co. No. 2 . .	8¢, bottled	84,000	9,500	12,000	42,600
Milk Co. No. 3 . .	8¢, bottled	84,000	73,500	179,200	
Milk Co. No. 4 . .	8¢, bottled	43,000			
Milk Co. No. 5 . .	8¢, bottled	12,000,000			
	6¢, in bulk	4,060,000	39,000,000		53,000,000

The very considerable variation in number of bacteria present in different samples of milk from the same dairy is shown by figures given for Milk Co. No. 2 and No. 3.

These analyses were made in the fall. During the summer the number is much greater. This is due to the fact that low temperatures hinder the growth of bacteria. The average number of bacteria in the milk sold in New York City during the cold winter months is about 300,000, while during the summer the average is about 2,500,000. Even though no specific disease bacteria can be shown to be present, it has been found that the consumption, especially by children, of milk containing a large number of bacteria is harmful and in the case of infants frequently proves fatal. Although no legal limit has been placed on the number of bacteria which may be present in milk which is sold in cities, 500,000 per cubic centimeter has been proposed as a limit for this purpose. Good milk should contain a great deal less than this number. In order to prevent the sale of milk containing an excessive number of bacteria, the board of health of the city of New York has for a good many years enforced the rule that no milk shall be brought into the city which is not at or below 50° F.

Influence of the milk supply on the death rate of children. The influence of the character of the milk supply on the death rate of children is shown by the results of experiments carried out by Dr. William H. Park and Dr. Emmett Holt.

TABLE XIV

EFFECT OF MILK SUPPLY ON DEATH RATE OF INFANTS UNDER ONE YEAR OF AGE DURING THE THREE SUMMER MONTHS

Kind of milk	*Per cent*
Milk in bulk (store milk)	20
Condensed milk	20
Bottled milk	9
Straus Station milk (Pasteurized)	3
Certified milk or breast milk	none

It is apparent that one child in five is sacrificed by using a contaminated milk supply. During the nine cool months of the year these investigators found that the character of the milk used did not affect the death rate of the children, undoubtedly because the number of bacteria in all grades of milk during this time of year is very low.

Determination of the number of bacteria. As the wholesomeness of milk can be judged from the number of bacteria present, the determination of this number is very important. Fortunately the method of counting bacteria is fairly simple, if the proper preparation is made. A measured volume of milk is placed on a plate containing a sterile nutrient medium, which is composed of meat extract and peptone to nourish the growing bacteria, and gelatin or agar-agar to make a semisolid medium in which the bacteria will remain fixed. Each bacterium multiplies rapidly, forming a colony around it, which soon becomes large enough to be visible to the eye alone or under only very slight magnification. By counting these spots or colonies the number of bacteria originally present in the milk can be ascertained. If the number of bacteria present in the milk is large, a definite amount of the milk is diluted with a definite amount of sterile water and a portion of this solution taken for the test. When many colonies are formed on a plate, the colonies on only a small portion of the plate are counted and the total number estimated. The determination is at best only approximate, as under the conditions of incubation all of the bacteria do not grow sufficiently to be counted. All material and apparatus used must be thoroughly cleaned and sterilized by heat so as to kill all organisms present, except those in the milk to be tested.

EXPERIMENT

12. Bacteria count. *Sterilization of apparatus.* Clean thoroughly 100 test tubes and insert firmly a plug of cotton in each test tube. Clean the Petri dishes and the 1-ccm. pipettes. Place the pipettes in a copper tube having a close-fitting cap, or in a large test tube closed with a plug of cotton. Sterilize this apparatus by placing it in an air oven heated to 150° C. for one hour. Prepare sterile water by nearly filling a 250-ccm. flask with distilled water and boiling vigorously for fifteen to twenty minutes. Insert a plug of cotton and allow to cool.

Preparation of nutrient gelatin. Place 500 gm. of lean beef in a large beaker or flask and add 1000 ccm. of distilled water. The meat must be as free as possible from fat and chopped fine or run through a sausage grinder. Place a piece of new cotton flannel, with the wool side up, in a large funnel and cover with a layer of clean cotton wadding. Filter the meat infusion through the flannel, squeezing out the last portions. It is advisable to place a second smaller funnel containing the same filtering medium below the first funnel, so that the filtered solution from the first funnel passes through the second, thus giving a very clear solution. Allow the solution to flow into the inner vessel of an agateware double boiler of at least two quarts' capacity. This vessel should be weighed empty as well as after receiving the meat infusion. Add an amount of Witte's peptone equal to 1 per cent of the weight of the infusion, and 10 per cent of the best quality of sheet gelatin (gold label). Dissolve the peptone and gelatin by stirring with a thermometer and heating the solution, not allowing the temperature to rise above 60° C. For this purpose the outer vessel only of the double boiler is heated with the Bunsen burner, the inner vessel being surrounded by the hot water. After the gelatin is dissolved the water in the outer vessel is brought to a boil and kept boiling for thirty minutes, the inner vessel being covered.

Adjusting the acidity. After the boiling has continued for twenty minutes withdraw 5 ccm. of the solution with a pipette and place in a porcelain dish or casserole. Add 45 ccm. of distilled water and boil for one minute over the Bunsen-burner flame. Add 1 ccm. of phenolphthalein solution [1] and titrate while hot (preferably while boiling) with N/20 caustic soda.[2] Add the soda solution until within a drop or two of the end point (a faint pink coloration). Cool by standing the dish in cold water, and if a distinct pink color does not develop, add the soda solution drop by drop until the end point is reached.

So much of the acid in the solution must be now neutralized that the amount of acid remaining in 1000 gm. will neutralize 10 ccm. of normal caustic-soda solution. The calculation of the amount of soda to be added is made as follows: If the 5-ccm. portion titrated required $4\frac{1}{2}$ ccm. of the N/20 soda solution, and the weight of the solution is 950 gm., the entire solution will require 855 ccm. of the N/20 soda, or 42.7 ccm. of normal soda. As the acid equivalent to 10 ccm. of normal soda solution must be left free, 32.7 ccm. of normal soda solution is added.

To coagulate finely suspended matter so that the solution may be filtered clear, the white of an egg is added at this point. The solution

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[1] This solution is prepared by dissolving one tenth of a gram of the crystals in 100 ccm. of 95 per cent alcohol.

[2] A normal solution of caustic soda contains 40 gm. of sodium hydroxide dissolved in enough water to make 1000 ccm. As even the poorest caustic soda generally contains about 90 per cent of sodium hydroxide, about 44 gm. must be taken. A twentieth normal solution (N/20) is made by diluting 50 ccm. of the normal solution to 1000 ccm. with distilled water. For accurate methods of making these solutions, see the author's textbook on "Quantitative Chemical Analysis."

is cooled to 60°–70° C. by immersing the containing vessel in cold water, and the white of an egg added with stirring; it is then heated in the double boiler and finally boiled for two minutes over the free flame, with constant stirring. Weigh and add distilled water to make up for loss by evaporation. Take out 5 ccm. and titrate with N/20 sodium hydroxide and calculate the acidity as before. If the acidity per 1000 gm. is less than 8 ccm. or more than 12 ccm. of normal acid, acid or alkali should be added to bring the acidity to the standard 1 per cent. Take out another 5-ccm. portion and titrate a third time to ascertain if the adjustment of the acidity has been correctly carried out.

Sterilization of the culture medium. Filter the solution again through absorbent cotton and cotton flannel, passing the filtrate through the filter until clear. The nutrient gelatin must now be measured off in 10-ccm. portions into the sterilized test tubes closed with cotton plugs. For this purpose a glass tube graduated every 10 ccm. is convenient. The cotton plug is removed from a sterilized test tube and held between the first and second fingers, and again inserted into the test tube as soon as the 10-ccm. portion of gelatin has been added. The gelatin should not be allowed to touch the upper portion of the test tube, which is set aside in an upright position to cool. When all of the gelatin has been measured out into test tubes, it is sterilized by heating for five minutes in an autoclave at 120° C., which is the temperature of steam at 15 pounds' pressure. The tubes of gelatin must be kept in an ice chest. If the gelatin has not been completely sterilized, colonies will make their appearance in a few days.

The gelatin may also be sterilized by heating in steam for twenty minutes for three successive days, being kept in the ice chest when not being heated.

Count of bacteria. To make the count of bacteria in water or milk, the sample must be taken in a sterilized glass-stoppered bottle. It is advisable before sterilization to cover the stopper with tin foil to prevent entrance of bacteria with the dust from the air; 1 ccm. is withdrawn[1] with a sterilized pipette and transferred to a sterilized test tube and 9 ccm. of sterilized water added. This gives a dilution of 1 to 10. By diluting this solution in the same manner a dilution of

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[1] When bottled milk is being tested, the bottle is thoroughly shaken, the cap removed, and the 1 ccm. portion withdrawn.

1–100 is obtained. Most samples of milk must be diluted again, giving 1–1000. Very impure milks require still another dilution. A clean pipette must be used for each dilution. To one of the sterilized Petri dishes 1 ccm. of the 1–100 dilution is transferred, and to the second dish 1 ccm. of the 1–1000 dilution. Tubes of the nutrient gelatin are melted by placing in warm water, the plug of cotton removed, the open end of the test tube sterilized by passing it through the flame of a Bunsen burner, and the gelatin poured into the Petri dishes. The covers are raised only when pouring in water or gelatin so as to prevent the entrance of bacteria from atmospheric dust. The milk and nutrient gelatin are mixed by slightly tilting the dish, so

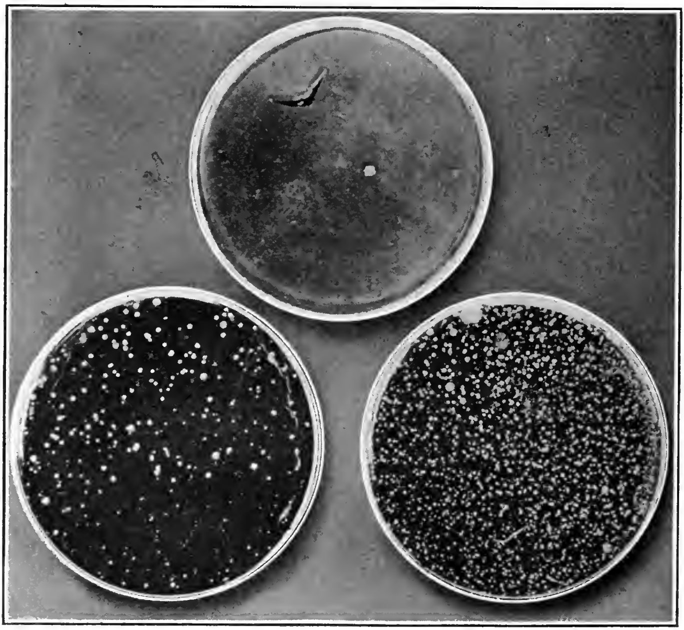

Fig. 9. Plate Cultures of Bacteria

Each spot was produced by a single bacteria. The upper plate contains sterilized milk, the left-hand plate certified milk, and the right-hand plate ordinary milk that the contents flow from one side to the other. The dish is then placed in a horizontal position in a thermostat or refrigerator kept at about 20° C. After forty-eight hours the number of colonies on the plate are counted. If the number is not over 200, the total number may be counted. If the number is large, some counting device must be employed. This generally consists of a plate marked off in sections or other divisions, in such a manner that the total number may be counted; the average number of colonies per division is then obtained by counting the number of colonies in several divisions, so as to obtain a fair average of the number per division. Small specks of dust must not be mistaken for colonies which are circular in shape. The count must generally be made with a small magnifying lens. When the colonies are small it is sometimes advisable to allow the sample to incubate for seventy-two hours. This fact should be stated, however, in reporting the analysis. The best results are generally obtained by counting the colonies on plates containing about 200.

Preparation of nutrient agar-agar. When this medium is prepared the meat is soaked in one half the quantity of water; that is, 500 ccm. Fifteen grams of thread agar are dissolved in 500 ccm. of water by boiling for one-half hour. The amount of water lost is then restored and the infusion allowed to cool to about 60° C. The remaining operations are identical with those used in preparing gelatin, except that 2 per cent of Witte's peptone is dissolved in the filtered meat infusion, after which the agar is added to the meat infusion, care being taken to keep the temperature below 60° C.

The samples of milk are plated as described for gelatin. It is necessary, however, to heat the agar to a higher temperature in order to melt it. It should be cooled to about 40° C. before pouring on the plate. The plates are incubated at body temperature ($37\frac{1}{2}$°–40° C.) for forty-eight hours. The number of colonies obtained is usually higher than with gelatin. It is advisable to use porous earthenware covers with agar to prevent the spreading of colonies by the condensation of water.

CHAPTER VI

FATS AND OILS

Importance of fats in the diet. Fats and oils constitute one of the most important constituents of our food. From one eighth to one third of the total amount of food ordinarily taken is fat or oil. As the energy derived from this class of foods is more than double that obtained from the same weight of the other food constituents, it is evident that fats and oils furnish fully half the energy obtained by human beings from their food. This fact has been popularly recognized so long that the word "fat" has become synonymous with "rich" or "superabundant." Fats also exert a beneficial influence on the digestive process, so that a diet without fat is dry and unpalatable.

Percentage of fats in foods. Fats are very seldom consumed in the pure state, but are generally combined or blended with other foods. A large proportion of foods in their natural state contain an appreciable proportion of fat. In fact, all of the fats and oils used for food have been separated from the other constituents with which they are naturally blended.

Vegetables and fruits contain very little fat. Bread and other cereal products and some kinds of fish contain only small amounts. For this reason the addition of butter or salad oil renders these foods more palatable and nutritious. Most meats, as well as a great many nuts and other seeds, contain a large proportion of fat. The following table gives the percentage of fat present in a number of common foods.

TABLE XV

Percentage of Fats in Ordinary Foods

	Per cent		*Per cent*
Sirloin steak	17	Coconut	50
Roast beef	28	Chocolate	50
Leg of lamb	13	Oatmeal	7
Ham	40	Bread	1¼
Bacon	64	Vegetables	1
Salt pork	85	Fruits	½
Cheese	33	Butter	85
Salmon	17	Olive and salad oils	100
Bluefish	1		

Chemical composition of fats. Fats are composed of the same chemical elements as carbohydrates; that is, carbon, hydrogen, and oxygen, although the proportion of oxygen is very much less than in carbohydrates. For this reason more than double the amount of heat or energy is given out during their combustion. Fats are also much more complex in structure. If an oil is kept at a low temperature for some time, it separates into two constituents, one of which is solid, and the other liquid. The solid constituent can be separated by filtration from the liquid fat or oil. If the two constituents are allowed to remain together and the mixture warmed, the solid melts so that the oil resumes its original appearance. Its properties are not quite the same as before, however. It is a well-known fact that olive oil which has been frozen will not make as good a salad dressing as the unfrozen oil. In a similar manner a solid fat may be heated to a point where only a portion is converted into an oil. The solid portion may be separated by filtration and is known as stearin. Both solid fats like tallow, and oils like cottonseed oil, are converted on a commercial scale into more desirable products in this manner. From the tallow a hard solid (stearin) and an oil is obtained. By cooling the cottonseed oil, cottonseed stearin may be separated out and the remaining oil will remain liquid at much lower temperatures than the original oil.

Glycerin and acids found in fats. It is possible to carry the decomposition of both the stearin and the oil still further. There are a number of methods of carrying out this decomposition, but by each there are obtained as invariable constituents both glycerin and one or more of the so-called fatty acids. Experiments of this kind show that almost all animal and vegetable fats and oils are composed of glycerin in combination with one or more of the fatty acids, most natural fats and oils containing several acids. Some of these acids form fats which are liquid at ordinary temperatures, and are therefore called oils, while others form solid fats. Oleic acid is the most common of the fatty acids which produce oils, while stearic and palmitic acids constitute the bulk of solid fats. A fat like lard, which melts easily, contains a large proportion of oleic acid, while beef and mutton tallow, which melt at a much higher temperature, contain a large proportion of stearic acid. These acids are always combined with glycerin in the natural state of the fats or oils. An oil does not contain free oleic acid. It contains olein, which is the name given to the compound formed when oleic acid combines with glycerin. Similarly, tallow contains palmatin and stearin; that is, compounds of palmitic and stearic acids with glycerin. The percentage of glycerin is quite small, averaging 8 per cent for the common fats.

Decomposition of fats. As the glycerin and the fatty acids are not very firmly combined, most fats are quite easily decomposed. Heating with steam and action of bacteria or of digestive fluids are some of the common ways in which fats are decomposed. The characteristic odor emitted when foods are fried with fat of any kind is produced by acrolein, a product of the decomposition of glycerin. The disagreeable odor of rancid butter is due largely to the liberation of one of its fatty acids known as butyric acid, which has a very characteristic and disagreeable odor. In the process of making soap, fats are decomposed by means of caustic soda or potash, commonly known as soda lye or potash lye. In this process the fatty acid combines with the soda or the potash and forms soap. When this reaction is brought about, the fat is said to be saponified. The glycerin is set free and may be allowed to remain in the soap, or may be separated and purified to be used for pharmaceutical purposes or in the arts.

The fatty acids. The following table gives the names and chemical formulas of the fatty acids found in ordinary

TABLE XVI

ACIDS FOUND IN FATS AND OILS

Name	Chemical formula	Where found
Butyric . . .	$C_4H_8O_2$	Butter
Caproic . . .	$C_6H_{12}O_2$	Butter, coconut oil
Caprylic . . .	$C_8H_{16}O_2$	Butter, coconut oil
Capric	$C_{10}H_{20}O_2$	Butter, coconut oil
Lauric	$C_{12}H_{24}O_2$	Coconut oil
Myristic . . .	$C_{14}H_{28}O_2$	Coconut oil
Palmitic . . .	$C_{16}H_{32}O_2$	Nearly all oils and fats
Stearic	$C_{18}H_{36}O_2$	Nearly all oils and fats
Arachidic . .	$C_{20}H_{40}O_2$	Peanut oil, coco butter
Behenic . . .	$C_{22}H_{44}O_2$	Oil of ben
Lignoceric . .	$C_{24}H_{48}O_2$	Peanut
Oleic	$C_{18}H_{34}O_2$	Nearly all oils and fats
Rapic	$C_{18}H_{34}O_2$	Rape mustard
Linolic	$C_{18}H_{32}O_2$	Cottonseed, corn, almond, peanut, olive
Erucic	$C_{22}H_{42}O_2$	Rape mustard

fats and oils. The chemical formulas show that they are composed of three elements only; that is, carbon, hydrogen, and oxygen, and that the amount of oxygen is quite small.

The flavor of oils. In addition to the fatty acids and glycerin, there are present in oils small quantities of other chemical compounds which give distinctive flavors or odors. Some oils contain constituents which are either poisonous, like croton oil, or have a disagreeable taste or smell, and for this reason cannot be used for human food. Others have constituents which possess medicinal properties, such as castor oil and cod-liver oil. The oils which do not contain deleterious or medicinal constituents may be used as foods. The following vegetable oils are of this character: almond oil, coconut oil, cottonseed oil, corn oil, hazelnut oil, olive oil, peanut oil, rape oil, sesame oil, sunflower oil, and poppy-seed oil. All of these oils will not be used to any great extent in a given country, as the people will generally use most largely the oils which can be most easily produced in that country, although taste and cost will influence consumption. In nutritive value there is very little difference between these oils. There seems to be a considerable difference in digestibility, which is apparently dependent on the fatty acids which constitute the oil. The oils most largely used in the United States for food are olive and cottonseed.

Coconut oil. This oil resembles butter fat more than any other natural fat or oil, and has therefore been largely used in making artificial butter. It is made from the ordinary coconut by pressing the flesh until the oil flows out.

Cottonseed oil. This oil is most largely used for food purposes in the United States, and has also displaced the use of other oils to a great extent in Europe. The enormous amount of 3,200,000 barrels containing 50 gallons each are produced yearly. Between 2,000,000 and 2,500,000 barrels, or 125,000,000 gallons, of this amount are used for food. If equally divided, this would give each man, woman, and child in the United States about a gallon and a half, which is therefore the average per capita amount of this oil consumed each year by the people of the United States. The following table gives the purposes for which the cottonseed oil is used:

TABLE XVII

Consumption of Cottonseed Oil for the Year 1905

	Domestic	Foreign
	Barrels	*Barrels*
Salad oil	280,000	360,000
Cooking and baking	170,000	16,000
Compound lard	1,000,000	100,000
Oleomargarine	10,000	250,000
Packing sardines	50,000	30,000
Soap making	450,000	200,000
Other purposes	145,000	44,000

The oil press. The process of extracting the oil from the cottonseed and refining it until it is suitable for food is quite complicated. The cotton gin, which separates the seed from the fiber, to be used as cotton, leaves a considerable amount of short fiber known as "linters." In the oil mill the linters are first removed, after which the seeds are chopped up by rapidly revolving knives and passed over shaking screens, which shake out the meats, the hulls being passed on to the hull pile. The meats containing from 30 to 36 per cent of oil are first passed between heavy rolls and then cooked in steam-jacketed kettles and pressed in hydraulic presses between camel's-hair press cloths. About 85 per cent of the oil flows out through the press cloth. The cake remaining in the press contains about 7 per cent of oil and 38 per cent of protein, and is largely used as a cattle food.

The refining of oil. The crude oil thus obtained must be refined. For this purpose it is heated and agitated in large tanks with dilute caustic soda, which combines with the free fatty acids in the oil and also removes resinous coloring matters. After allowing the impurities to settle, the clear yellow oil is drawn off, dried, and filtered. This is known as "Prime Summer Yellow" cottonseed oil. It is further refined by filtration through Fuller's earth and subjected to a deodorizing process. This oil is sold under various brands for cooking purposes.

Lard substitutes. Large quantities of this oil are used for the preparation of "snowdrift," cottolene, and other substitutes for lard. These products are made by melting up in the heated oil 15 to 20 per cent of oleostearin. The melted fat is then cooled suddenly by passing over artificially cooled rolls. It then very closely resembles lard in appearance and properties.

Salad oil is prepared by chilling the highly refined cottonseed oil until the "cottonseed stearin" crystallizes out. This so-called "stearin" is, in fact, palmitin. The oil is pressed out of this semisolid mass. Cottonseed oil is used very largely for frying, since it will stand a higher temperature without smoking than lard or butter. Large quantities are also used in making artificial butter.

Olive oil. This is the most highly prized oil for table use. This preference is largely due to its very agreeable flavor. It has been used as a food from the very earliest times of which we have any historic record. It is no more nutritious than the other edible oils. It is about five times as expensive, however, as cottonseed oil. On account of its high price it has been very largely adulterated by the admixture or substitution of cheaper oils. If not more than 20 to 30 per cent of a foreign oil is present, it is almost impossible to distinguish by taste between the pure and the adulterated oil. In the United States cottonseed oil has been most largely used as the adulterant, while in Europe sesame and peanut oils have been largely used, while castor oil, lard oil, fish oil, and even petroleum have been found as adulterants. Olive oil contains olein and palmitin, but very little stearin. From 3 to 20 per cent of palmitin is present.

Various grades of olive oil. The greatest care is taken in the preparation of olive oil. The olives must be hand picked. If they are shaken down and bruised, the oil is not of so fine a flavor as when made from fruit whose flesh is entirely unbroken. The olives should be cold-pressed to produce the finest oil, which is called "virgin oil." If the olives are heated, the oil begins to decompose so that some of the acid is separated from the glycerin, which injures the flavor. If perfect olives are cold-pressed, a perfectly neutral oil is produced. The residue from the first cold-pressing is heated and again pressed, thus producing an additional quantity of oil, which is of inferior quality to the virgin oil. This oil may be refined by a process similar to that used for cottonseed oil, and is then suitable for use as a food, but it is not of so fine a quality as the virgin oil, which requires little or no refining. A third quality of oil may be obtained by treating the residue from the hot presses with carbon disulphide or petroleum ether. These liquids dissolve the oil and are then distilled off to be used again. The oil obtained in this manner should not be used as a food, but is suitable for soap making. If too great pressure is used in obtaining olive oil, the hard kernel of the fruit is crushed and an oil pressed out of the kernel which is similar to the oil from the flesh of the fruit but distinctly inferior.

Other food oils. By similar processes the oil is pressed out of various seeds and nuts, such as hazelnut, peanut, rapeseed, sesame, sunflower seeds, etc. Some of these oils are very palatable and easily digested. Their nutritive value is very nearly the same as that of the cottonseed and olive oil. The preference for one or the other of these oils is largely a matter of flavor.

EXPERIMENTS

13. Production of stearin. Place a sample of cottonseed or olive oil in ice and salt. For this purpose the oil may be placed in a bottle or test tube. When thoroughly cooled, a white solid will separate out. This is the so-called cottonseed-oil or olive-oil stearin. It may be separated from the liquid portion by squeezing through cloth of suitable fineness. If allowed to become warm, the stearin again goes into solution in the oil.

14. Determination of acidity. As the glycerin is not very firmly combined with the fatty acid, the latter is set free when the fat or oil is heated and becomes rancid, or even when allowed to stand for some time. The amount of free acid may therefore be taken as an index of the method of production or refinement, age or condition of the fat or oil, the best oils being nearly neutral.

The determination is carried out as follows: From 1 to 10 gm. of the fat or oil, depending upon the amount of fatty acid present, are weighed out and transferred to a small flask. The fat is dissolved in 50 ccm. of neutral alcohol or the same quantity of a mixture of equal parts of alcohol and ether, if the fat does not dissolve in alcohol alone. One drop of phenolphthalein is added and then fifth-normal caustic soda[1] introduced drop by drop from a

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[1] For the preparation of this solution see p. 190. More accurate results may be obtained by the use of an alcoholic solution of caustic potash. For the preparation of this solution see the author's text on "Quantitative Chemical Analysis," 4th ed., p. 437.

burette with constant and vigorous shaking until a pink color is produced. The first appearance of the pink color is taken as the end point. It may fade on standing a few minutes, but this is due to saponification of the neutral glycerides by the excess of alkali.

The result is expressed in per cent of oleic acid. One ccm. fifth-normal alkali is equal to 0.0564 gm. of oleic acid. If 3 ccm. of the alkali is required to titrate the free acid in 2 gm. of fat, the percentage of free acid is 8.46 $\left(\frac{0.0564 \times 3 \times 100}{2} = 8.46\right)$.

When carrying out this determination on butter, the fat must be melted at the lowest possible temperature and the water and casein allowed to settle out. The clear fat is drawn off and used in making the test for acidity. If borax or boric acid has been added as a preservative, it will be present in the water, which may be tested for the preservative in the manner given on page 41.

15. Soap making. In the process of making soap the fatty acids are separated from the glycerin by boiling with caustic soda or potash, the soap being the compound formed by the union of the alkali with the fatty acid. This process may be carried out as follows: 15 gm. of solid caustic soda are dissolved in 120 ccm. of water. One half of the solution is poured into a suitable vessel, an equal volume of water and 50 gm. of tallow, cottonseed, castor, or other oil added. The mixture is brought to a boil and kept boiling for about half an hour, water being added to replace that lost by evaporation. If tallow has been used, it will be necessary to add the remainder of the caustic solution and continue the boiling for another hour, finally allowing the liquid to become more concentrated. About 20 gm. of salt are then added and the solution boiled for a few minutes and then allowed to cool. The soap rises to the top and solidifies to a hard cake. The glycerin and excess of caustic are present in the brine.

16. Preparation of stearic acid. A portion of the soap made in the preceding experiment is dissolved by heating with soft or distilled water. If the saponification or conversion of the tallow or oil into soap has been complete, a clear solution will be obtained.

Dilute hydrochloric acid is added to this solution until it is decidedly acid. The liquid will become turbid on account of the separation of the free fatty acids, mainly stearic and oleic. On warming the solution and allowing it to stand for some time, the fatty acids will collect as an oily layer on top of the solution and will solidify on cooling. This white fatty substance is what is sold as stearic acid.

17. Test for cottonseed oil. As cottonseed oil is very cheap as well as quite palatable, it is very apt to be used as an adulterant of more expensive fats and oils. Fortunately it can be easily tested for. For this purpose a solution known as Halphen's reagent is used. It is made by dissolving 1 gm. of sulphur in 100 ccm. of carbon disulphide and adding an equal volume of amyl alcohol. Equal volumes of this reagent and the oil to be tested are mixed in a test tube and heated by immersion in boiling water, or, still better, boiling saturated brine. After heating for about fifteen minutes a red color is developed if cottonseed oil is present. The delicacy of the test may be studied by applying it to samples of oil containing known amounts of cottonseed oil. For this purpose 10, 20, and 50 per cent of cottonseed oil may be added to olive, lard, or other suitable oil and the test applied. It will be observed that the depth of the color will give some idea of the amount of cottonseed oil present.

CHAPTER VII

BUTTER AND ITS SUBSTITUTES

Production of butter. Butter is the product obtained by a process having for its object the separation of the fat of milk in a relatively pure form. The first step in this process consists in the production of cream. While milk contains only about 3½ per cent of fat, cream may contain as much as 40 per cent, the remainder being casein, which is the protein of milk and water. The fat is present as minute globules, which are surrounded by a layer of casein. These globules are so small and light that they float in the whey of the milk. When the cream has become acid by the action of bacteria, it is subjected to a vigorous agitation known as churning, by which the casein is separated from the fat, which then unites to form large masses of butter, the composition of which is given in the following table:

TABLE XVIII

Composition of Butter

	Per cent	*Per cent*
Fat	80 to 85	average 84
Water	7 to 16	average 12.8
Salt	2 to 3	average 2.0
Sugar	0.3 to 0.5	average 0.4
Protein	0.6	
Coloring matter		

As is shown by the table, butter is not 100 per cent fat, but still contains some water, casein, sugar, and salt as ordinarily consumed.

Butter fat. The butter fat could easily be separated in pure condition, but it would not be as palatable an article of food as the butter to which we are accustomed. The fat, however, is the essential constituent of butter. It is to obtain this constituent that man so universally and commonly uses butter in his daily diet. Butter fat is undoubtedly the most readily digested and easily assimilated of this class of foods. It is also more agreeable in flavor than any other fat. In chemical composition butter fat is similar to the other common vegetable and animal fats and oils; that is, it is composed of glycerin and a number of fatty acids of which oleic and palmitic constitute about 71 per cent. About 20 per cent is composed of volatile fatty acids. The peculiar characteristics of butter are undoubtedly due to the presence of these acids. One of these acids has taken its name from butter, being called butyric acid. The average composition of butter fat is given in the following table:

TABLE XIX

Composition of Butter Fat

Acids	*Per cent*	*Acids*	*Per cent*
Dioxystearic	1	Lauric	2.57
Oleic	32.50	Capric	0.32
Stearic	1.83	Caprylic	0.49
Palmitic	38.61	Caproic	2.09
Myristic	9.89	Butyric	5.45
Glycerin	5.25 per cent		

Constituents of butter. The various constituents of butter may easily be separated in the following manner: A piece of butter is placed in a test tube or other glass vessel. It is melted by placing the vessel in warm water or by applying other gentle heat and then allowed to stand for a few moments. The butter fat forms the clear upper yellow layer. Underneath the fat the casein collects as a white solid, while at the bottom is formed a colorless, watery portion which is a solution of the salt and the small amount of sugar present in the butter.

The flavor of butter. Considerable care is necessary to produce butter having a perfectly sweet and agreeable flavor. While this does not add directly to the nourishing constituents of an article of food, it is of great value in inciting the flow of the digestive fluids and promoting good digestion, especially in the case of persons of acute sensations. Delicacy of flavor also adds very materially to the price which may be obtained for an article of food. The development of flavor in butter seems to be due entirely to bacterial action. By introducing pure cultures of the right kind of bacteria into sweet cream, butter of most excellent flavor will be obtained. Other bacteria develop very disagreeable odors and tastes. By controlling the bacterial content of the cream, the best modern dairies produce butter of very uniform and excellent flavor. Much butter, however, is still produced by small dairies according to old-fashioned methods by which any bacteria by chance present are allowed to act on the cream before it is churned. Carelessness in handling both cream and butter leads in many cases to the production of butter which is far too rancid and disagreeable in flavor to be sold for table use. Much of this butter is subjected to a process of purification.

Renovated or process butter, as such a purified product is called, has been treated as follows: The poorly made butter is first melted in large tanks. By blowing air through the melted fat most of the disagreeable odor is removed. The casein and brine which are allowed to settle to the bottom of the tank contain most of the bacteria producing the decomposition and disagreeable taste. The clear fat, which is now quite sweet, is drawn off and mixed with sweet milk and the whole churned. The remainder of the process is identical with that of making butter from cream. The resulting product has generally a fairly sweet odor and taste and finds a ready market. It differs somewhat in composition from that of true butter. While it is a wholesome and nutritious article of diet, it is inferior in flavor to good butter and is sold at a much lower price. In most states its sale is carefully regulated by law, with the intent that the purchaser shall clearly understand that he is not buying creamery butter. For this purpose the words "renovated butter" must be printed on the package and also displayed on a conspicuous sign over the article on sale.

Oleomargarine or butterine. This is the name given to butter substitutes in which a portion or all of the butter fat has been replaced by a foreign fat. As has been already stated, all fats are very similar in composition, and only a small portion of the constituents of butter fat differs from other ordinary fats and oils. The attempt has therefore been made to find a combination of various animal and vegetable fats which is similar in composition and properties to natural butter fat. The manufacturer is restricted to fats and oils which are cheaper than butter fat and can be readily obtained. For this and other reasons the attempt to make artificial butter has been only partially successful. A perfectly wholesome and nutritious product has been obtained without, however, having the flavor of butter nor its peculiar adaptability to the digestive system, so that it can be continually eaten with relish. For this reason some natural butter is almost invariably mixed with the artificial product in order to give it an agreeable taste and odor.

Wholesomeness of oleomargarine. The manufacture of oleomargarine is carried on under strict government control and inspection so that no unsanitary methods nor unwholesome ingredients are allowed to be used. As the ingredients used are wholesome and nutritious articles of food, oleomargarine cannot be condemned as a food. The opposition to it has arisen from the fact that it has often been offered and sold as butter. This practice not only defrauds the customer but tends to drive the genuine article out of the market, as it cannot be produced at as low a cost as oleomargarine. When sold for what it is and at a lower price than butter, oleomargarine undoubtedly renders the fat element of human diet available to people who could not afford the more expensive butter. While a good grade of oleomargarine is a more wholesome and palatable

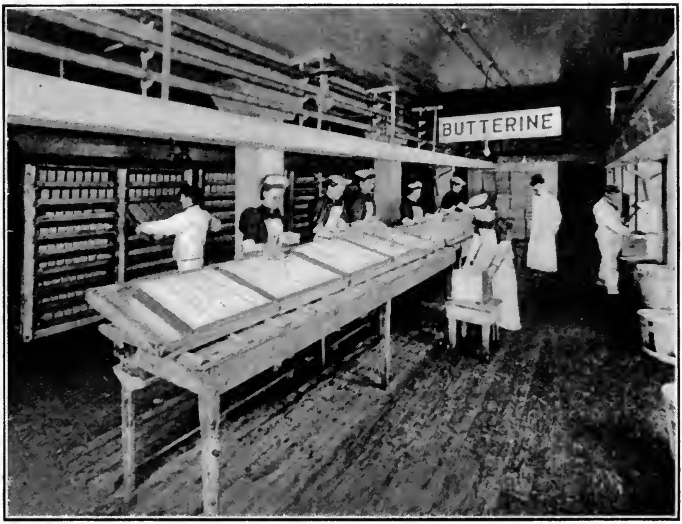

FIG. 10. Wrapping and Packing Butterine for Shipment

article of food than a poor grade of butter, the best grades of butter have a finer flavor and are more easily assimilated than any substitute as yet produced. The keeping qualities of good oleomargarine are excellent. Mixtures of oleomargarine and butter in various proportions are very palatable and considerably cheaper than pure butter.

The practice of coloring butter with vegetable or aniline dyes is very general, but if the dye is not a poisonous one, there can be little objection to the practice.

Manufacture of oleomargarine. Both animal and vegetable fats and oils are used in the manufacture of oleomargarine. The finest neutral lard is heated to 45° C. for some time and then subjected to hydraulic pressure. Most of the stearin is removed in this manner and used for other purposes, while the oleo oil forms the raw material for the manufacture of the artificial butter. The most commonly used vegetable oil is cottonseed, which together with oleo oil and milk are placed in churning machines which serve to beat the oils into minute drops resembling the condition of the fat in natural butter. In some cases coloring matter is added as well as substances which give taste and odor similar to butter. Generally a small amount of butter is also introduced for the same purpose.

EXPERIMENTS

18. The foam test for butter. Place a tablespoonful of pure butter, renovated or process butter, and oleomargarine in each of three small beakers or other suitable vessels. Heat over the Bunsen burner or a stove until the samples melt. On continued heating, the butter boils quietly, producing considerable foam, while the oleomargarine and the renovated butter produce very little foam and sputter and crackle violently.

19. The milk test. Place a tablespoonful of each of the three samples used in Experiment 18 in each of three small beakers or small cups containing a few ounces of sweet milk and warm gently until the samples are melted. Place the vessels in cold water, and while the fat is still melted, stir vigorously with wooden sticks of convenient size. As the fat hardens, it will be found that the pure and renovated butter will make an emulsion with the milk very similar to cream, while the oleomargarine will not mix with the milk but will solidify into a solid chunk of fat, which will often adhere to the stick so that it can be lifted out of the milk.

As cottonseed oil is frequently used in the manufacture of oleomargarine, the test for this oil by means of Halphen's reagent, as given on page 70, is of great assistance in proving the presence of oleomargarine.

CHAPTER VIII

MEATS

The importance of meat in the diet. Meats are of importance in the human diet on account of their high content of protein. The solid portion of the lean of meat is very nearly pure protein, containing only very small amounts of fat, carbohydrates, and mineral matter. The average composition of lean meat may be given as 25 per cent protein and 75 per cent water. The presence of protein in the human diet is of the highest importance, because the protoplasm or living portion of the human system can be built up and nourished only by this constituent of our food. If it were entirely absent, we should starve to death as certainly as if we ate no food at all, although by no means as quickly.

FIG. 11. A Train of Cattle Cars bringing Stock from the Western Plains to Chicago

Substitutes for meat. We are by no means compelled to eat meat in order to obtain this valuable constituent of our food, because many vegetable foods contain protein in large amounts. It seems, however, that the protein of meat is much more easily digested and more readily assimilated by the tissues than vegetable protein, so that meats are a very desirable constituent of the human diet. Most meats as ordinarily consumed contain considerable quantities of fat, so that when eaten with potatoes, which are composed almost entirely of starch, the combination furnishes all constituents of a complete diet. As meats are a relatively expensive food, economy as well as good health is attained by limiting their consumption to the amount actually necessary to meet the needs of the system.

Fig. 12. A Portion of the Chicago Stockyards

The danger of excessive use of meat. On the other hand, serious dangers attend the consumption of meats, especially in excessive quantities. This is due to the fact that the decomposition products of protein are not readily eliminated from the system, and give rise to various disorders and diseases. The proteins of meat also seem more liable to decompose in such a manner as to give rise to highly poisonous substances. The consumption of meat should therefore be limited to the amount necessary to build up and repair the tissues of the body. As both growth and the breaking down of the tissues are very slow processes, the amount of protein consumed need not be large. It must not be forgotten that all vegetable foods contain some protein, and some of these foods contain a very large percentage of this constituent. One half pound of lean meat per day taken with other ordinary foods is therefore amply sufficient for the average adult.

Unsanitary meat. Meats may be unwholesome for a number of reasons. The animal from which the meat is derived may be diseased at the time of slaughter. Such diseases are not necessarily communicated to the person eating the meat, although in some cases they may be. This is true of trichina in pork and tuberculosis in cattle. The animal also may not be of the proper age for slaughter. The slaughter of very young calves is generally prohibited by law, their flesh not being fit to eat. The meat should not be eaten if the animal has died a natural death. The meat from perfectly healthy and sound animals may be rendered unfit for food by unsanitary methods of slaughter and handling of the meat.

Inspected meat. As it is almost impossible in many cases by an examination of meat or meat products to obtain evidence that the animals were unfit for food or that the meat was improperly handled, an essential part of any effective method of protecting the public against an unwholesome supply is a rigid inspection of the animals before slaughter, as well as the method of handling the meat until it reaches the consumer. Such a system of inspection is now maintained by the national government.

Characteristics of sound meat. The purchaser may, however, in many cases distinguish between wholesome and unwholesome meat by an inspection of the article as offered for sale. Sound fresh meat should have the following characteristics: The color should be neither pale pink nor dark purple. In the first case the animal was probably diseased; in the second case it was not slaughtered but died a natural death. Fresh meat should be firm and elastic to the touch and should hardly moisten the finger. Wet, sodden, or flabby meat, which is soft and jellylike to the touch, should not be used. Moreover fresh meat should be almost free from odor. Diseased meat has a sickly disagreeable odor. On standing a day or two it should grow drier, but should not become wet. The following simple chemical tests may also be applied in doubtful cases: It should be acid toward litmus or other indicator; that is, it should turn blue litmus paper red. If it is neutral or alkaline, preservatives such as borax have been used. When dried at 100° C. it should not lose more than 70 to 74 per cent in weight. Unsound meat may lose 80 per cent or more. On cooking, it should shrink very little.

Similarity of various kinds of meat. Although the various kinds of meat, such as pork, beef, mutton, etc., differ considerably in taste and ease of digestion, chemically they are so similar that it is quite difficult to identify the ingredients of a mixture of these meats if they have been chopped fine so that no large pieces remain.

Refrigeration of meat. The only method of preserving fresh meat, which is generally conceded to be unobjectionable, is by refrigeration. There is some difference of opinion as to how long meat may be kept in this manner without deterioration. Some observers report that the meat begins to deteriorate after three months, while other investigators find no change after as many years. It seems, however, that the condition of the meat is affected by the temperature to which it is exposed and also by the conditions under which it is allowed to thaw. To obtain the best results, the meat must be subjected to a temperature low enough to freeze it solid; that is, none of its juices should remain liquid. This result is obtained with beef by keeping it at a temperature at or below – 9° C. or 16° F. When such meat is thawed, it should be allowed to warm up very slowly, as otherwise it will be flabby. This is due to the fact that during the process of freezing the juices have been forced out of the cells. If warmed up slowly, these juices reënter the cells slowly, so that the meat assumes its natural firm condition.

Fig. 13. Meat in Cold Storage

Chemical preservatives. These substances have been used quite extensively in preserving meats. Boric, sulphurous, and benzoic acids have been most generally employed. In addition to preserving the meat, sulphurous acid has also the property of giving it a bright red color. Saltpeter or potassium nitrate has the same effect on the color of the meat, but this salt has very little preserving power. Meat which contains a chemical preservative will emit no disagreeable odor, even when it is so old and decomposed that without the preservative it would be quite foul. If sulphurous acid is used, the meat will also retain the bright red color of fresh meat. The use of these substances, therefore, renders possible the sale of meat which would otherwise be discarded. Such meat is sometimes used for the preparation of sausage. The sulphurous acid is introduced as sodium or calcium sulphite. The red color is sometimes

Fig. 14. Packing Poultry for Shipment

restored to decomposed meat by the addition of coal-tar dyes, cochineal, or red ocher.

Objections to the use of preservatives. The treatment of meat with coloring matter or preservatives is to be condemned, and the sale of such meat is illegal. While it is possible to find preservatives and coloring matter that are not demonstrably unwholesome in the minute amounts that it is necessary to employ, it is obvious that if the meat were in good condition, neither preservatives nor coloring matter would be necessary. As these substances are added for the purposes of deceiving the customer, their use is fraudulent. The use of saltpeter or potassium nitrate in corned beef is not considered fraudulent, because the meat so treated is not injured, and the custom has been long established.

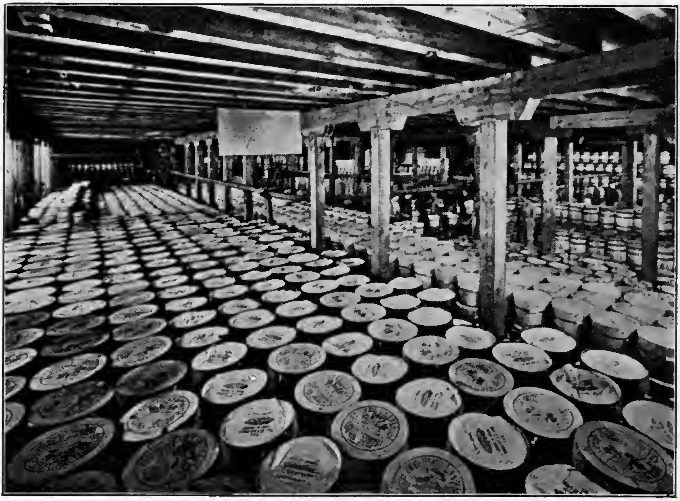

Fig. 15. A Roomful of Lard

Gelatin. This is one of the most commonly used of meat products. It is a nitrogenous substance, which has the property of forming a jelly with a very large amount of water. Good gelatin will form a jelly with fifty times its weight of water. It is extracted from the bones, tendons, and hides of the slaughtered animals. Tendons and hides are first treated with lime to remove hair and dissolved mucin. After washing, the gelatin is dissolved out by means of hot water. Sulphurous acid is sometimes added in order to produce a white product. After drying and powdering, the gelatin is ready for use. It is not present as such in the bones, hides, etc. A substance called collagen, very similar to gelatin, is present and is converted by the hot water into gelatin. Gelatin is a perfectly wholesome article of food if carefully made from fresh material. It decomposes very readily and may be contaminated with tetanus and other disease bacteria unless the greatest cleanliness is observed during its manufacture.

EXPERIMENTS

20. Testing meat for borax. Test samples of meat for borax or boric acid according to the method given in Experiment 10, p. 40. Prepare samples of meat containing borax by sprinkling the powder over the surface of the meat. Use a portion of the sample for making the test for borax, and set aside the other portion for observation on the preservative action of the borax, a sample of the untreated meat being placed with the preserved sample.

21. Testing meats for sulphites. Sulphites are largely used to preserve and give a bright red color to chopped meats or "Hamburg steak." Samples of such meat may be tested as follows: A small portion is placed in a small dish or beaker and moistened with dilute phosphoric acid and then heated gently. If a large amount of sulphite has been added, the sulphur dioxide evolved on heating can be detected by the odor, which is that of burning sulphur.

A much more delicate test consists in exposing a piece of starch-iodate paper to the action of the gases and steam arising when heating the meat with phosphoric acid. If sulphites are present, the paper is turned blue. The starch-iodate paper is prepared by first making thin starch paste. The starch is made into a thin paste with cold water, which is diluted by adding a considerable amount of boiling water while stirring continually. A few crystals of potassium iodate are dissolved in water and added to the starch paste. Strips of filter or other porous paper are then dipped into the solution and drained and allowed to dry. This paper should be preserved in well-stoppered bottles.

A still more delicate test for sulphites is carried out as follows: 40–50 gm. of the meat to be tested is mixed with water and heated for a few minutes. Ten ccm. of glacial phosphoric acid is added and the solid material strained off through a cotton cloth. The solution is then placed in the second flask, shown in Fig. 16, and distilled. The water in the first flask is brought to a boil. The steam entering the second flask heats the solution of the meat. The Bunsen burner under the second flask is then lighted and the flame of the Bunsen burners regulated so that the meat solution is kept gently agitated without any great change in volume. The distillate is received in a beaker containing a little bromine water. After about 200 ccm. has been distilled over, the bromine is boiled out, a little hydrochloric

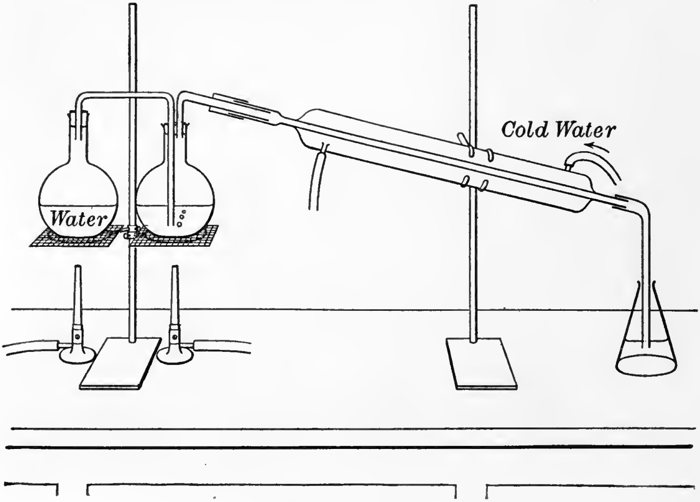

Fig. 16. Distillation of Sulphurous Acid

acid is added, and then a few drops of a 10 per cent barium chloride solution are added to the boiling hot solution. After boiling for some time, the solution is set aside to cool and examined carefully for the presence of a precipitate. A white precipitate is evidence that a sulphite has been added to the meat. A very slight precipitate is generally obtained, even from pure meat, because the protein of meat contains a small amount of sulphur, part of which is carried over during the distillation process.

Tests should be carried out on samples of pure meat before and after the addition of weighed amounts of sulphites. Sodium or calcium sulphites may be used for this purpose.

The amount of sulphite which has been added to the meat may be accurately determined by weighing the barium sulphate obtained in the distillate from a weighed amount of meat. For this purpose the precipitate is filtered off on an ashless filter paper and washed thoroughly with hot water. The wet paper with the precipitate is placed in a weighed crucible and the paper burned by gently heating the crucible, which is finally strongly heated, cooled, and weighed. One gram of barium sulphate is equivalent to 0.2745 gm. of sulphur dioxide.[1]

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[1] For detailed instructions for this determination see the author's textbook, "Quantitative Chemical Analysis."

CHAPTER IX

CARBOHYDRATES

Starch, Sugar, and Sirups

Importance of carbohydrates in the diet. While generally occurring in natural products together with other constituents, this important class of foods may be separated in a very nearly pure condition, just as fats and protein are available without admixture with other food constituents. As the human system seems to be able to obtain the necessary supply of energy most economically from carbohydrates, their preparation as food is very important. This consists essentially of two processes: first, their separation from other substances with which they are associated in natural products; and second, the converting of insoluble into soluble compounds. Starch is the most common insoluble form, while the sugars and sirups, honey, etc. are common illustrations of soluble carbohydrates. Starch is a very large constituent of nearly all seeds and grains, such as wheat, corn, rice, etc., while the sugars are present in large quantities in nearly all fruits and in the juices of many plants, such as sugar cane, the maple tree, etc.

Necessity of cooking starch. The digestion of starch consists essentially in its conversion into simple soluble forms. In the preparation of food products the starch may be subjected to a similar process so as to render it more or less soluble. It is then more easily digested. It is very essential to start this conversion before starch is eaten, as raw starch is quite indigestible. The process of cooking by roasting or boiling renders the starch sufficiently soluble for rapid action by the digestive fluids. On the other hand, it is not advisable to consume only starch which has been fully converted into soluble forms (mainly the sugars), because such food is almost immediately taken into the circulation.

FIG. 17. Steel Tanks for the Storage of Corn

Each tank will hold 85,000 bushels, or 85 carloads of corn, which is converted into starch, glucose, etc. in three days

At least some food is needed which will dissolve gradually and nourish the system continuously. A diet containing both soluble and insoluble carbohydrates, such as sugar and starch, is best suited to meet the needs of the system.

Natural products containing starch. While a very large portion of the starch consumed as food is taken in its natural condition in such foods as potatoes, rice, bread, and the numerous foods prepared from corn, oats, etc., it is found convenient for many purposes to separate the starch in the pure state. Corn and potatoes are the natural products which have been most largely used for the manufacture of starch. Both of these foods are composed almost entirely of starch, the process of manufacture consisting simply in the elimination of the other constituents. As corn can be produced in abundance and cheaply in the United States, it is the source from which most of the American starch is made, while for analogous reasons the potato has been used in Europe.

Structure of a grain of corn. An examination of a grain of corn will show that it has an outer hard hull or shell which protects the grain from injury. If a grain be split parallel to the flattened sides, the soft germ can be seen imbedded in a mass of starch. When the germ sprouts through the action of moisture and warmth, the starch is converted into sugars, which dissolve and are absorbed and nourish the growing plant. The germ contains a considerable amount of protein and oil, while some protein, known as gluten,[1] is also mixed with the surrounding layers of starch. Processes have been developed for separating the starch, protein, and oil very completely.

Separation of the germs. For this purpose the grain is first steeped in water containing sulphurous acid. This softens the entire grain, loosens the hull from the remainder of the grain, and dissolves the gluten which serves to bind the starch grains together. The soft corn is then passed through the so-called "foose mills," which break the grains of corn into coarse particles. It is then mixed with water and pumped into the "germ separators," which are

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[1] This gluten is not identical with the gluten of wheat. It is composed of two proteins, edestin and zein, while the gluten of wheat is composed of glutenin and gliadin.

long, deep, steel tanks. The ground corn suspended in the water is delivered into the upper end of these tanks. The germs being light, on account of their content of oil, float on top and are swept to the lower end by means of strips of wood, which are moved slowly over the surface of the liquid by means of belts to which they are attached. The starch and hulls being heavy drop to the bottom and are carried away in separate conveyors. In this very simple manner the germs which have been left practically intact are separated very completely from the starch and hulls.

Production of corn oil. By subjecting the germs to pressure corn oil may be produced, which is used for making soap, or, when refined, as a cooking oil; or it may be converted into a substitute for rubber. The germs remaining in the strong canvas bags of the oil press form what is known as "oil cake." This still contains a small amount of oil as well as a large amount of protein and starch and some mineral matter. It has been found to be an excellent cattle food and is largely used by dairymen to increase the yield of milk and butter.

Manufacture of starch. The starch and hulls which settle to the bottom of the "germ separators" are next passed over the so-called "shakers." These consist of frames covered with perforated copper, copper gauze, or silk bolting cloth. By means of machinery they are kept in constant motion, back and forth, which gives the name "shaker" to the apparatus. The finer particles of the starch pass through the shaker, while the coarse particles, consisting of hulls with some attached starch, are carried over the end of the shaker. This material is again ground in bur or stone mills, and again passed over shakers in order to remove the remainder of the starch from the hulls. The starch which has passed through the shakers is held suspended in water, forming the so-called "starch liquor," which is pumped to the starch tables. These are long wooden troughs slightly inclined. The starch liquor enters the trough at the upper end, and as it flows slowly to the lower end the starch settles to the bottom, forming a compact layer, while the gluten and the water flow out at the lower end. The starch is then shoveled into conveyors, which carry a portion of it to the drying rooms to be made up into the various forms of dried starch. A single factory produces annually 75,000,000 pounds of starch in this manner from corn.

The conversion of starch into sirup and sugar. While a considerable quantity of starch is used in foods, laundry work, and many technical processes, a very considerable proportion is converted into glucose or corn sirup and starch sugar. These substances are chemically very similar to starch, differing mainly in that they are soluble and sweet, while starch is very insoluble and almost tasteless. They are also much more easily digested. When starch is to be converted into glucose, or starch sugar, it is suspended in water and a small amount of hydrochloric acid is added. The starch liquor is pumped into closed copper tanks, called "converters," in which it is heated by means of steam under pressure. Under these conditions the starch undergoes a transformation by which it takes up a small amount of water and forms soluble compounds similar to sugar, so that the liquor acquires a sweet taste. Because the starch combines with water, this process is called hydrolysis. The compounds produced are mainly dextrine and dextrose. The first substance formed is dextrine, which may be called a soluble gum and is largely used for mucilage and other pastes. The same substance is formed in the crust of bread during the process of baking. On further heating with acid, the dextrine breaks down still further into two sugars, maltose and dextrose. On continued heating the maltose is also broken down into dextrose, leaving this product only. The sugars are not the same as ordinary granulated or cane sugar, which is known as sucrose. Dextrose is less sweet than sucrose, so that glucose is only about three fifths as sweet as ordinary sugar. If the heating of the starch liquor is prolonged, the starch is converted almost completely into dextrose, which crystallizes out and forms what is known as starch sugar or corn sugar.

Fig. 18. Top of Charcoal Filters
The sirup flows into the filter through the curved pipes

Purification of the sirup. After the starch has been converted into sugars in this manner the hydrochloric acid is

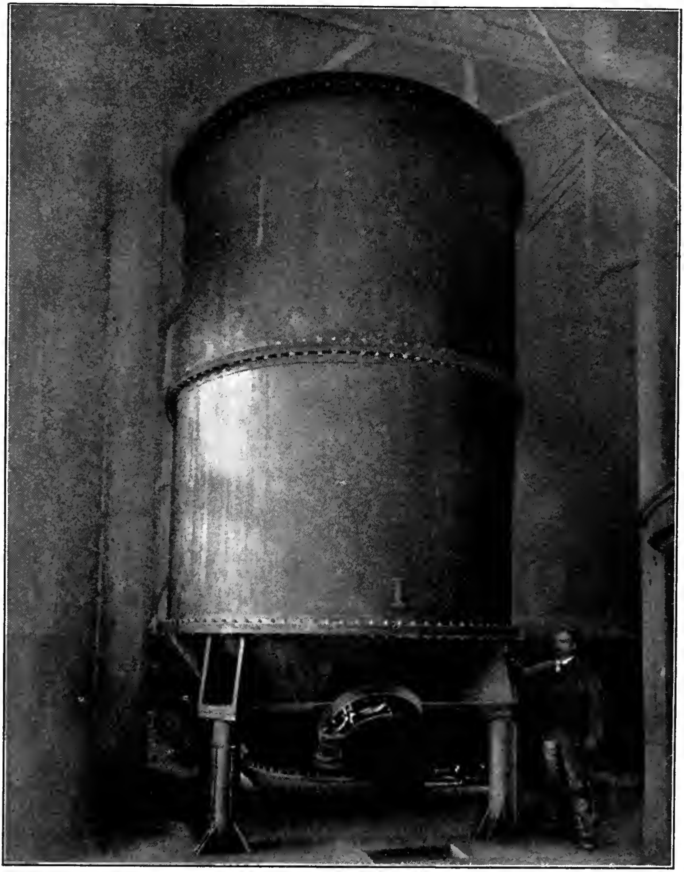

FIG. 19. Body of Charcoal Filter, which is a Steel Tank entirely filled with the Sirup and Charcoal

neutralized with soda ash and converted into sodium chloride, which is the main constituent of common salt. Some of the impurities in the liquid separate out at this stage of the process and are removed by filtration through canvas

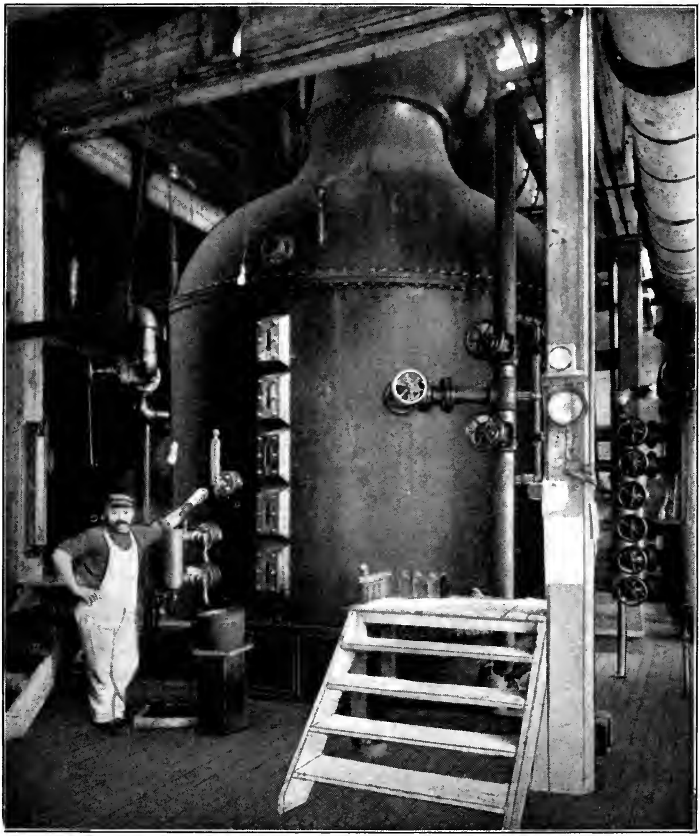

Fig. 20. Vacuum Pan for Concentration of the Sirup
The capacity of the pan is 100 barrels of sirup

in filter presses. After passing through these presses the solution is clear and transparent, but dissolved impurities give it a yellow color. To remove these impurities and decolorize the solution, it is passed into large steel tanks filled with bone char. The charcoal or carbon present in this material absorbs the impurities and clarifies the solution. The same material is used in the same manner for clarifying solutions of ordinary sugar, or sucrose. The bone char may be used repeatedly, as the impurities are burned out in specially designed kilns.

Concentration of the sirup. In the next and final step in the process the solution is converted into a thick sirup by removing the excess of water. This is done by boiling the liquid in a vacuum until the desired concentration has been reached. The finished product is a thick, colorless, transparent liquid known as glucose, or corn sirup. Formerly sulphurous acid was added to prevent its turning yellow. On account of the pure-food agitation this practice has been discontinued except when the glucose is exported to countries where the presence of sulphurous acid is not prohibited.

Composition of corn sirup. Glucose, or corn sirup, therefore, is a solution of dextrose and dextrine and similar sugars, in smaller amount, as formed by the chemical combination of water and starch. These compounds are formed whenever starch is heated to the proper temperature. However, when moist starch is heated, dextrine is the main product produced. This is quickly hydrolyzed by the saliva, forming maltose and dextrose, which give the sweet taste. For this reason a baked potato is sweeter than a boiled potato, and the crust of bread sweeter than the interior. Many natural products, especially fruits, contain large quantities of the same compounds. Honey is a natural "sirup," which is very similar in composition to glucose, or corn sirup, containing dextrose, levulose, and sucrose, but no maltose. The only compound present in glucose which is not derived from the starch is the salt formed by the neutralization of the hydrochloric acid with soda ash. The word " glucose " means *sweet* and was adopted for this reason. The name " corn sirup " has been adopted in this country because it is made from corn and has the physical properties of a sirup. In Europe, however, glucose is made almost entirely from potato starch and sometimes from broken and low-grade rice.

Table sirup. Most of the table and cooking sirups on the market to-day are composed very largely of corn sirup. It cannot be used in the pure state for this purpose because it is quite insipid. It is therefore blended with "refiners' sirup," or molasses from the sugar refiners, which has generally too strong a flavor to be used alone. Glucose is also very extensively used in the manufacture of candy. It is also largely used in the manufacture of jams, jellies, and other fruit preparations, as well as for many other minor purposes.

Nutritive value of glucose. Because glucose is rarely ever sold at retail in the pure state under its own name, or used as such in the household, but has invariably been sold in combination with some other food and under some other name, without any statement or intimation of its presence, it has almost universally been considered an adulterant. This classification has been correct because the purchaser almost always was under the impression that sugar had been used in the preparation of the product obtained. The assumption that glucose is unwholesome or injurious or even of little or no food value is absolutely erroneous. On the contrary, it is a highly nutritious food, having an energy value of 1777 calories per pound, and is very readily digested and assimilated. It is inferior to cane sugar only in the matter of flavor. The only valid objection to its use is removed when, in accordance with pure-food laws, its presence is indicated on the label of foods which contain it.

Amount of corn used in producing corn products. Glucose will probably continue in the future, as in the past, to be an important part of our food supply. This is evident from the fact that about 36,000,000 bushels of corn are used annually for its manufacture in the United States. This amount of corn would require about 36,000 cars to haul it, and would make a single pile almost as high (500 feet) as Washington Monument (555 feet) in our national capital. This pile would be 500 feet high, with a base covering a space equal to several city blocks; that is, 500 feet long and 500 feet wide. There are made annually 1,000,000,000 pounds of corn sirup, which is sufficient to give to every man, woman, and child in the United States 12 pounds per annum.

Manufacture of cane sugar. The process of manufacturing ordinary sugar is much simpler. It exists as such in the juices of the sugar cane and sugar beet. The sugar cane is cut down and passed through presses, which squeeze out the juice. After the addition of a little slaked lime to remove impurities and to keep the juice alkaline, it is evaporated and the sugar crystallizes out. This is the raw or brown sugar. The sirup remaining after the sugar has been crystallized out is known as molasses. It contains the mineral matter present in the juices of the cane as well as any impurities which may have been introduced during the process. Raw sugar is also obtained from beets, the sugar in this case being dissolved out of the tissues of the finely divided beets by a process of diffusion.

Refining of cane sugar. In order to refine the crude sugar it is first moistened with sirup to dissolve the impurities and placed in a centrifuge. When this machine is rotated at a high speed, the sirup is thrown off the sugar crystals. These are then dissolved in water and phosphoric acid and lime added. The calcium phosphate formed in this manner carries down the suspended impurities, which are filtered off by means of canvas bags. The sirup is then filtered through bone char and concentrated in vacuum pans in exactly the same manner as the corn sirup. From the concentrated sirup the sugar crystallizes out and is placed in the centrifuge, where it is washed with water and then sprinkled with water containing a small amount of Prussian blue in order to counteract a slight yellowish tinge. After drying, the sugar is ready for sale.

EXPERIMENTS

22. Starch test. Test for starch several cereals and vegetables, as corn, wheat, potatoes, etc. The starch test may often be obtained on vegetables by applying a drop or two of iodine solution (prepared as in Experiment 1) to the freshly cut surface of the vegetables. The test may be obtained in all cases by crushing a small portion of the vegetable or grain and treating with boiling hot water for a few minutes. On allowing to cool and adding a few drops of the iodine solution a deep blue coloration or precipitate is produced.

23. Conversion of starch into sugar. The conversion of starch into sugar may be shown by the following experiment: Starch paste is first made by moistening a few grains of starch with water and adding boiling water with constant stirring. A few cubic centimeters of hydrochloric acid are added and the boiling continued. Before adding the acid a few drops of the starch solution is diluted with water and iodine solution added. This test is repeated at five-minute intervals. At each successive test the blue color becomes fainter until replaced by a brown color, indicating that the conversion of the starch is completed.

The solution may now be neutralized with sodium carbonate, which is added until the solution no longer turns blue litmus paper red. It is generally quite cloudy at this point and should be filtered. It may then be concentrated by boiling until a sirupy consistency is reached.

24. Action of diastase on starch. The natural process of conversion of starch into sugar by the enzymes present in the grains may be shown as follows: 26 gm. of malt are ground in a mortar and treated with 1 ccm. of cold distilled water for an hour and then filtered. The diastase of the malt is dissolved by the water. Equal parts of this solution and some thin starch paste are mixed and kept at a temperature of 55° C. The conversion of the starch may be observed by means of the iodine test, as directed in Experiment 22.

Various malt extracts (maltine for instance) may be purchased and used in place of the diastase extracted directly from the malt. The rapidity with which equal portions of such extracts convert the same starch solution may be used as a measure of their strength.

25. Digestion of starch. The conversion of starch into sugar by the natural process of digestion may be illustrated by the following experiment: A few cubic centimeters of saliva are collected and filtered. A solution of boiled starch is prepared and cooled as directed in Experiment 22. The saliva is added, using about 10 ccm. to 100 ccm. of the starch solution. One half of the mixture is made slightly acid with hydrochloric acid. Both portions are tested with the iodine solution at regular intervals. It will be found that no conversion takes place in the acid solution. This shows how the acid gastric juice of the stomach stops the action of the saliva, and emphasizes the necessity of chewing the food and the evils of rapid eating. The starch in the alkaline solution will be more or less rapidly converted, depending upon the activity of the saliva, temperature, and amount of starch present.

CHAPTER X

CANDIES

Cocoa and Chocolate

Function of sugar in the diet. Sugars and sirups are used by many people for condimental purposes only; that is, they are added to foods for the purpose of giving a pleasant taste. As has been shown in the preceding chapter, these substances have a high energy value; indeed, most of the energy used by the human system is derived from this class of foods (the carbohydrates). So that when sugar is added to tea or coffee or any other food, its energy or food value is materially increased, the calorific value of sugar being 1860 calories per pound. The same is true of sirups, honey, and other sweet foods. While they are very palatable, they are also very nourishing, so that the energy available for the system is greatly increased by their consumption.

Food value of candy. Candy is generally eaten between meals without any thought of its food value. The gratification of the taste is frequently the only object sought, with the result that the system is overloaded and more or less serious consequences follow. This is more likely to happen on account of the very high calorific value of many constituents of candy. While glucose with 1777 calories has the same calorific value as sugar, chocolate has a much higher value; that is, 2864 calories per pound. Nuts have a similar value, peanuts, for example, giving 2560 calories.

Compared with these values, we find that the average value for meats is about 1000 calories, while vegetables and fish seldom give more than 500 calories.

Adult ration of candy and nuts. Candy must therefore be looked upon as one of our most highly concentrated and nourishing foods. This is strikingly illustrated by the fact that one and two-thirds pounds of chocolate creams give 3000 calories of energy, the equivalent of a day's ration for an active adult. As chocolate creams are composed almost entirely of carbohydrates, they would constitute a very poorly balanced ration. If part of the candy were replaced by peanuts, another highly concentrated food which is largely consumed between meals, a better balanced ration would be obtained. The following table gives the composition of a daily ration containing two thirds of a pound of peanuts and two thirds of a pound of chocolate creams. It is evident that not only are the required number of calories of energy obtained, but that the proper proportion between protein, fats, and carbohydrates is maintained in this small amount of two articles generally eaten at odd times merely to indulge the sense of taste.

TABLE XX

ADULT RATION COMPOSED OF TWO THIRDS OF A POUND OF CHOCOLATE CREAMS AND TWO THIRDS OF A POUND OF PEANUTS

	Peanuts	Chocolate creams	Total
Calories	1774	1200	2974
	Grams	*Grams*	*Grams*
Protein	75	7	82
Fats	110	26	136
Carbohydrates	73	220	293

Such a diet would not be desirable, because all of the carbohydrates would be present in very soluble form, a considerable portion of which should be replaced by starch.

Candy not a sustaining food. The fact that a taste for candy does not have to be acquired, but that every one has a natural appetite for such food, undoubtedly has a physiological explanation. This natural taste would seem to indicate a demand of the system for these very nourishing foods. The appetite seems to say, "Here is a food ready for use which can give me a great deal of energy very quickly." It is not, however, a sustaining food. One does not feel satisfied for any considerable length of time, as after eating an ordinary dinner. It goes into the blood quickly and is soon used up. Starch is a much better food, because it is digested more slowly, giving the system nourishment as it is required. Peanuts also could not be eaten continually in large quantities, on account of the presence of some constituent in small quantity which the system does not tolerate. It is evident, however, that sweetmeats have a very high food value and should not be eaten in large quantities in addition to the ordinary meals, neither should they be eaten to the exclusion of the former.

Sugars present in candy. The manufacture of sugar and glucose, which constitutes the larger part of most candy, has been described in the preceding chapter. Sugar consists mainly of one substance, sucrose, represented by the chemical formula $C_{12}H_{22}O_{11}$. Glucose is a mixture of a number of chemical compounds, although dextrose, maltose, and dextrine are the important constituents. Maltose has about the same formula as sucrose, $C_{12}H_{22}O_{11} \cdot H_2O$. Dextrose has the formula $C_6H_{12}O_6$, while dextrine is represented by the simpler formula $C_6H_{10}O_5$. When sugar is heated in the presence of an acid, the sucrose is broken down into two constituents, dextrose and levulose. These compounds are very similar to glucose in their properties. In making candy, therefore, very nearly the same result may be obtained by using a combination of sugar and glucose, or by simply boiling sugar with an appropriate acid, such as tartaric. The same decomposition takes place in the stomach when sugar is digested. There is very little candy made from pure sugar without glucose. These two constituents are equally wholesome and nutritious. While glucose is transparent and absolutely colorless when produced, it very soon begins to turn light yellow. The candy made from glucose is also not pure white. This difficulty is entirely avoided by the addition of a small amount of sulphurous acid to the glucose or the candy. Until recently this was the common practice in the manufacture of candy and glucose. It has been largely discontinued on account of the widespread belief that sulphurous acid is unwholesome, and the enactment of laws forbidding its use in articles of food.

Sulphurous acid injurious. On account of the small amounts of sulphurous acid ordinarily used in foods, no immediate ill effects can usually be observed from consuming food containing it. It has been shown, however, that the continual consumption of such foods tends ultimately to produce disease, especially of the kidneys, through which the acid must be eliminated. There is also the danger that, if its use in foods is allowed, excessive amounts will occasionally be added by careless or unscrupulous manufacturers, subjecting the consumer to very serious danger. Formerly sulphuric acid was very largely used in the manufacture of glucose. This acid was neutralized with lime, producing calcium sulphate, some of which remained in the glucose. While there is more objection to the presence

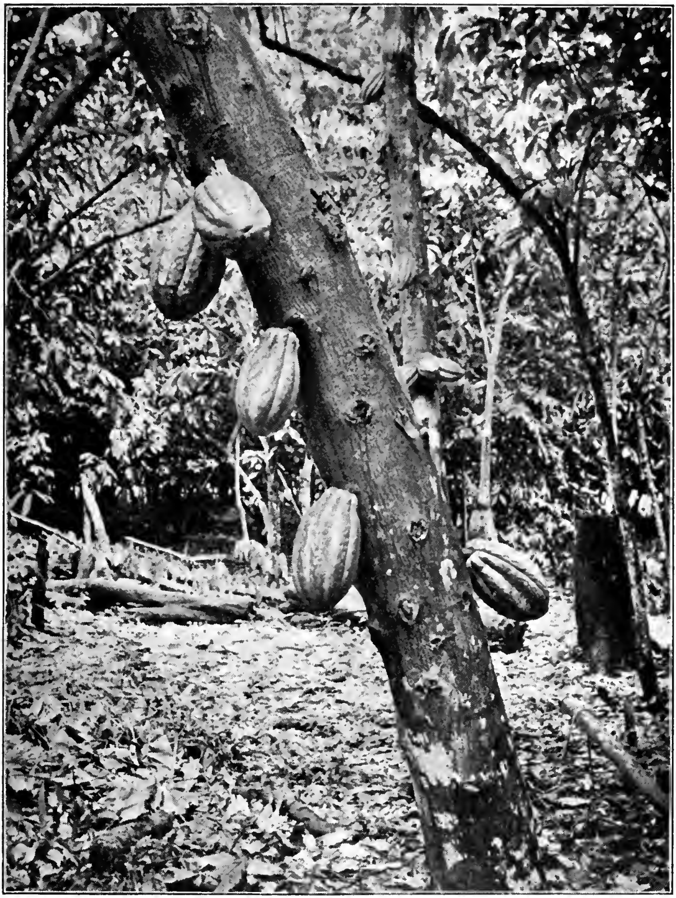

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FIG. 21. The Cocoa Tree, showing the Fruit growing on the Trunk

of this compound than to the presence of the salt which remains in the glucose as made at present with hydrochloric acid, it cannot be said that calcium sulphate is injurious in moderate amounts. This is evident from the fact that almost all natural waters used for drinking contain this substance.

Food value of chocolate creams. Chocolate is another very common constituent of candy. In the United States chocolate creams are the most popular and largely sold of all candies. The popular taste in this instance seems to have a correct physiological basis, since chocolate creams contain all the elements of a complete diet, namely fats, protein, and carbohydrates. The flavoring matter of the chocolate is also very agreeable to most palates.

History of cocoa. Chocolate is made from the cocoa bean, which grows on a tree which is indigenous to Central America. It was discovered by Cortes during his conquest of Mexico. The Mexicans had cultivated the tree and used the bean in much the same manner as we do at present. Cortes introduced its use into Spain, where it soon became very popular. From Spain its use spread to Italy, thence to France and to England. The young American colonists learned its use from the mother country, and as the people of the United States have prospered, the consumption of the products of the cocoa bean have steadily and rapidly increased, in spite of the fact that its use is generally considered a luxury. The botanist Linnæus gave it its name *Theobroma cacao*. *Theobroma* means "food of the gods," and undoubtedly was designed to express Linnæus' opinion of the delicate flavor of the bean. The word "cacao" is the Mexican name of the plant.

The cocoa tree. This tree flourishes both wild and cultivated in warm moist climates, such as Mexico and Central America, parts of South America, and other tropical regions. It grows best in sheltered valleys where a soft rich soil is kept moist by a neighboring river, and where it is sheltered by other and taller trees. Under these conditions it blossoms throughout the entire year. It has red flowers, which develop into a yellow fruit, about one thousand flowers being required to produce a single fruit. This is large, about 10 inches long by 4 inches wide. The soft pulp surrounds from 25 to 40 seeds, which are the cocoa beans of commerce. The fruit ripens at all times of the year, as is customary with tropical vegetation. The fruit is cut off the tree, split open, and the beans removed, and in some localities dried immediately in the sun. The better grades are first subjected to a fermentation process, which destroys certain bitter constituents.

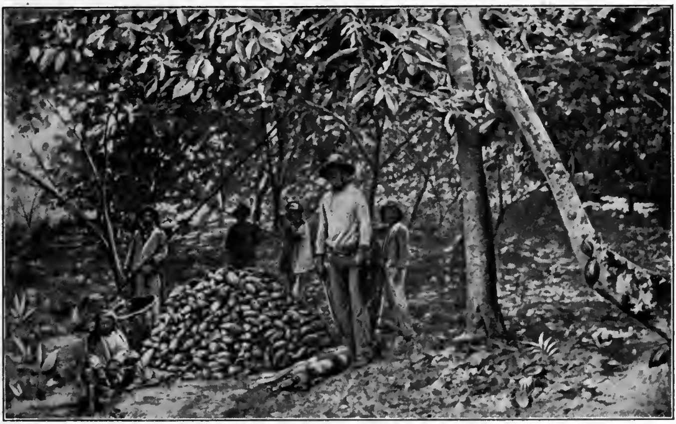

Fig. 22. Gathering the Cocoa Fruit

Roasting the beans. The flavor and other properties of the beans differ with the country in which they are grown. By carefully selecting and mixing different varieties of beans the best flavored chocolate is produced. When the beans are first brought to the factory, sticks, stones, and dust must be removed and the beans sorted to even sizes. The next process is the roasting of the bean. This is done by placing the raw beans in a steel cylinder, which is heated and revolved until the beans are uniformly roasted. The roasting develops the odor and flavor of the beans, gives them a brown color, and removes the stringent taste of the raw bean.

Cocoa hulls. The roasted beans are next placed in a machine in which the hulls are broken off and blown away. In the next operation the beans are crushed and the radical removed. The radical is a small germ from which the plant grows when the bean is allowed to sprout. About 16 per cent of the weight of the bean is lost in roasting and hulling, some of which is due to loss of moisture. A little of the fat also goes into the hulls, which contain 5 per cent of fat and about 0.8 per cent of theobromine. When boiled in water a liquid is obtained which has some of the properties of cocoa, but is of very little value as such. The hulls have been largely used as an adulterant. For this purpose they are ground and mixed with cocoa, spices, etc. They have some value as cattle food.

Cocoa butter. The meats of the beans, known as *cocoa nibs*, are next ground in stone mills. There are usually three mills in a set, so that the beans are ground three times. This reduces them to a thin paste, which is known as unsweetened chocolate, and which on cooling becomes a hard cake. It contains about 50 per cent of fat. From 40 to 50 per cent of this fat may be removed by subjecting the chocolate to moderate pressure in a hydraulic press, while if subjected to a pressure of 4500 pounds per square inch, 60 per cent of the fat may be removed. This fat is solid at the ordinary temperatures and is known as cocoa butter. It is used to a considerable extent in pharmaceutical and medical preparations, but most largely in the preparation of chocolate bars and the chocolate coating of candy.

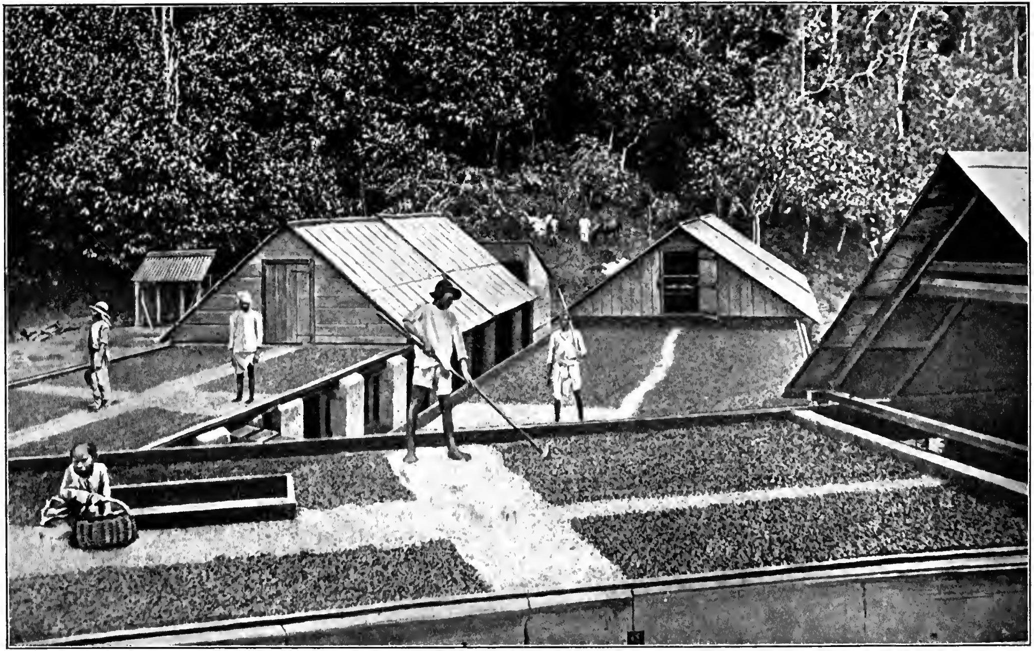

Fig. 23. Drying the Cocoa Beans in the Sun

Breakfast cocoas. These are prepared by grinding to a powder the chocolate from which a portion of the cocoa butter has been pressed out. The amount of fat remaining in the cocoa varies with the different brands. All of the fat contained in the chocolate cannot be allowed to remain, because the resulting cocoa would be too rich and indigestible for most people. As from 40 to 60 per cent of the cocoa butter is removed by means of hydraulic pressure, cocoa will contain from 28 to 38 per cent of fat, while unsweetened chocolate contains 50 per cent. In the preparation of some of the brands the cocoa is treated in such a manner that the fat which remains is more readily emulsified by water. By the Dutch process the cocoa is treated with hot water and alkalies, such as potassium, sodium, or magnesium carbonate. In the German process ammonia or ammonium carbonate is used. This results in the production of a purer cocoa, as in the subsequent roasting the ammonium compounds are entirely expelled, while the soda, potash, or magnesia introduced by the Dutch process remain in the finished cocoa. The presence of these constituents may be desirable for some people, while they could never be considered injurious. After a treatment of this kind the cocoa is powdered and is ready for use. The treatment with the alkalies has changed the cocoa in such a way that it remains suspended when boiled with water or milk, and does not so readily settle to the bottom of the vessel. The fat of the cocoa is also very probably rendered more easily digestible. Breakfast cocoa also contains from 6 to 24 per cent of proteids as well as from 14 to 28 per cent of starch and fiber (Table XXI, p. 112). Cocoa, therefore, contains all the constituents of a complete diet in quite large proportions. As the amount of water is small and proteids are generally expensive, cocoa is also a relatively cheap food.

Fig. 24. Roasting and Hulling Cocoa Beans

Composition of breakfast cocoas. The following table gives the composition of a number of the well-known brands of breakfast cocoa on the market to-day:

TABLE XXI

COMPOSITION OF BREAKFAST COCOAS

Brand	Water	Ash	Fat	Theobromine	Starch, fiber, etc.	Protein
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Huyler	4.27	5.54	34.04	1.02	18.70	17.29
Miller	3.99	4.05	38.76	1.06	24.17	6.77
Fry	4.33	4.28	31.16	1.36	28.23	12.78
Walter Baker . .	6.02	4.70	29.30	1.28	14.66	19.53
Van Houten (Dutch)	4.53	8.19	29.78	0.69	29.96	17.03
Bensdorp (Dutch)	4.59	6.69	33.06	0.88	19.85	11.41
Wilbur	3.84	4.69	33.32	0.82	22.78	16.74
Cadbury	4.00	4.70	27.58	0.70	27.53	13.58
Whitman . . .	2.70	4.15	37.68	0.66	20.36	14.13
Lowney	3.20	5.43	23.00		17.68	24.88

The large amount of ash in the Van Houten and Bensdorp brands, which are Dutch cocoas, is due to the presence of the alkalies introduced in the process of manufacture. It is evident that cocoa contains a great deal of nourishment, and that the beverage, especially when prepared with milk, has a high nutritive value in addition to the stimulating properties given to it by the theobromine and caffeine. Coffee and tea have similar stimulating properties but very little food value.

Adulteration of cocoa. While the removal of a portion of the fat of the chocolate for the manufacture of cocoa is desirable, the tendency is to reduce the amount of this constituent to the least that is acceptable to the public, on account of the high price and great demand for the cocoa

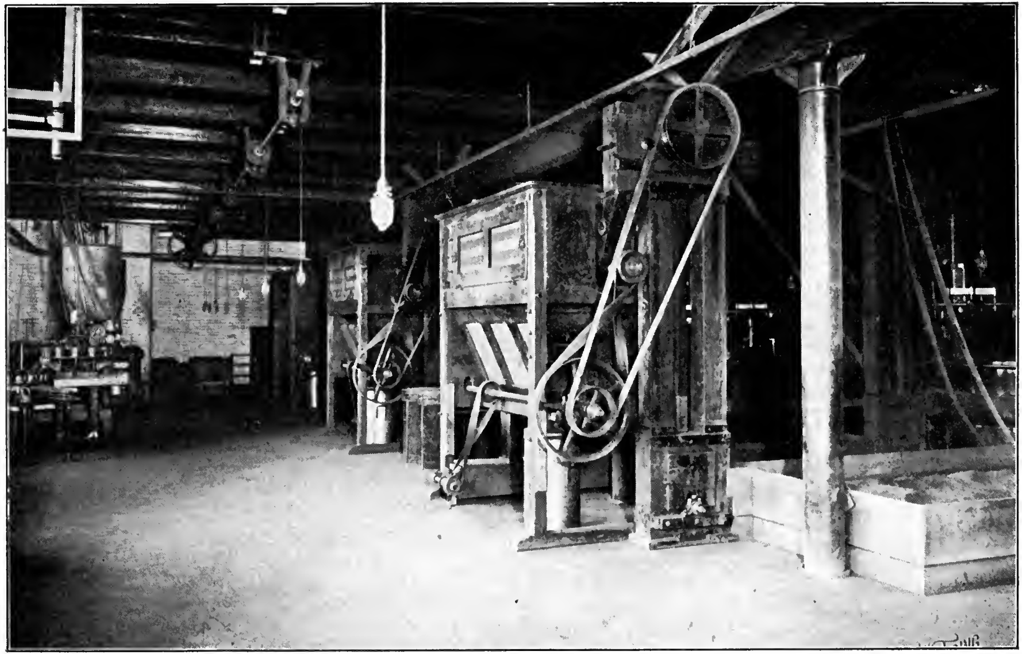

FIG. 25. Manufacture of Cocoa, showing the Sifting Machines

butter. Cocoa is also easily adulterated by the addition of the ground hulls, which have very little food value and little or no commercial value.

Chocolate. This is the name by which the ground cocoa bean from which no fat has been removed, is known. It is used pure and mixed with cocoa butter and sugar. The quantity of sugar varies from 50 to 70 per cent, while about 24 per cent of fat must be present. Its composition and that of chocolate creams is given in the following table:

TABLE XXII

COMPOSITION OF CHOCOLATE AND PEANUTS

	PEANUTS	CHOCOLATE		CHOCOLATE CREAMS
		Pure	Sweet	
Calories	2560	2860	2131	1800
	Per cent	*Per cent*	*Per cent*	*Per cent*
Carbohydrates	25	27.6		
Sugar			57	79.4
Starch			9.2	2.76
Fat	38	50	16.7	5.00
Proteids	26	12	4.0	1.2
Theobromine		1	0.4	0.1
Caffeine		0.4	0.1	0.04
Fiber		3	1.0	0.3
Ash	2	3	1.0	0.3
Water	9	3	10.6	10.6

It is evident from the table that the addition of sugar renders chocolate a better food because the unmixed product contains a larger percentage of fat than most people can readily assimilate. The addition of the sugar very materially reduces the percentage of protein. This element can readily be supplied by other foods.

FIG. 26. Grinding Cocoa Beans into Chocolate

Chocolate creams. In the manufacture of chocolate creams, cocoa butter is added to the chocolate in order to give the glossy appearance to the coating. The interior of the cream is composed of sugar and glucose, although various fruit jellies, nuts, etc., are dipped in chocolate in order to give variety to the candy. Fig. 28 shows a part of this process. On the right are seen double boilers in which the fondant is mixed with flavoring matter; on the left are seen the automatic molding machines wherein the fondant is cast in molds before being coated with chocolate. A large number of chocolate preparations have been made and sold, such ingredients as milk, cream, malt, oatmeal, nuts, etc., being used. Plain chocolate in bars, containing 60 per cent of sugar and 40 per cent of chocolate, is very popular in Europe. A thin coat of shellac varnish is very commonly used on chocolate and other candies in order to form a hard protective coating and prevent the candy from absorbing moisture and sticking together.

Adulteration of chocolate. Chocolate has been subjected to considerable adulteration. In the first place, the rather expensive cocoa butter has been replaced with various cheaper fats, such as beef stearin and coconut-oil stearin. A bean known as St.-John's-bread is sometimes ground and mixed with chocolate. This bean is quite sweet and has a fairly agreeable odor. A still more reprehensible practice consists in making an imitation chocolate from a mixture of iron oxide, gelatin, and sugar. The iron oxide is dark red and resembles the chocolate very closely. The gelatin gives the proper consistency to the mixture, and the gloss produced by the fat of true chocolate is imitated by a coating of shellac varnish. If the color of the chocolate cannot be matched, a little aniline dye is added.

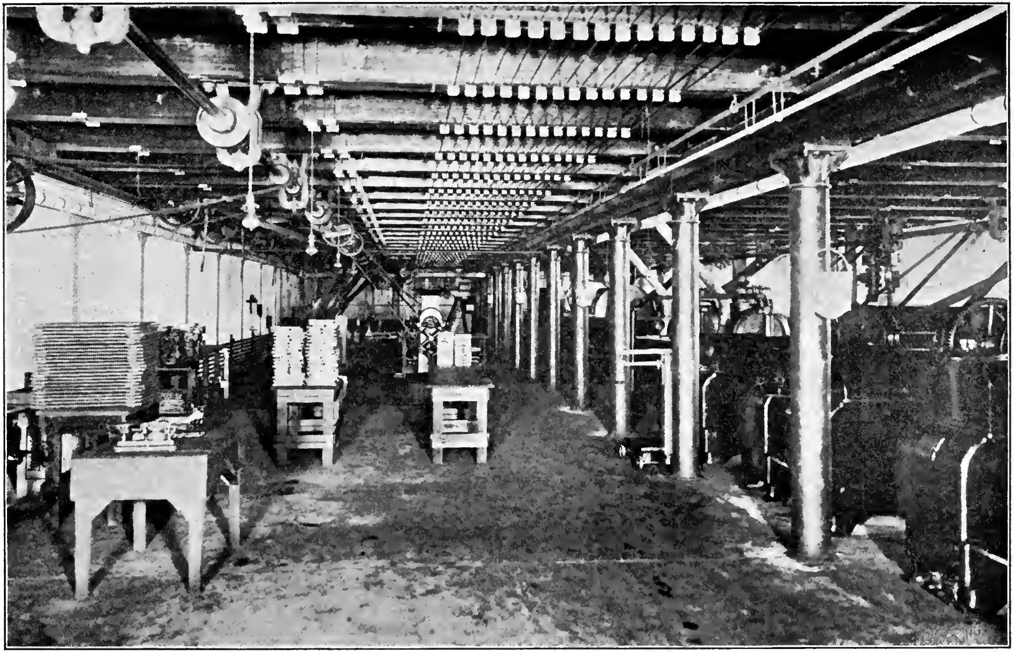

Fig. 27. Finishing and Molding Room

In the machines to the right, chocolate, sugar, and flavoring matter are mixed together. The tables and machines on the left are for molding purposes

Use of eggs in candy. A considerable number of other substances are used in small amount in candies. Among these are eggs. Since on account of natural causes, a large proportion of the eggs produced are obtained during the spring and summer months, while the consumption of this excellent food is distributed quite uniformly throughout the year, considerable difficulty is experienced in obtaining a supply of fresh eggs at all times. The candy manufacturer can quite easily utilize eggs preserved in such manner that they could not be sold to the ordinary consumer. Dried eggs are very convenient for the manufacturer. In countries where the supply exceeds the demand, the contents of the egg are removed from the shell and the yolk and white separated and dried. The yolk produces a powder, while the white produces flakes. As no portion of the food value of the egg is lost in this process, there can be no objection to the use of dried eggs, provided the process is carried out in a sanitary manner. At times, however, boric acid or other preservative is introduced, which remains in the candy. A still more reprehensible practice consists in the transportation of the broken eggs in the liquid state preserved with boric acid or formaldehyde. This practice has been largely prevented by the efforts of the pure-food authorities.

Gelatin. Eggs may be entirely replaced in candies by gelatin, which is considerably cheaper. Aside from its low nourishing properties, there can be no objection to this practice if a good grade of pure gelatin is used.

Coloring matter. This is very largely used in candies. While it is considered fraudulent to color or dye many food products, this is not true in general of candies. If some substance is colored to imitate chocolate, and thereby deceive the consumer, it would be considered illegal.

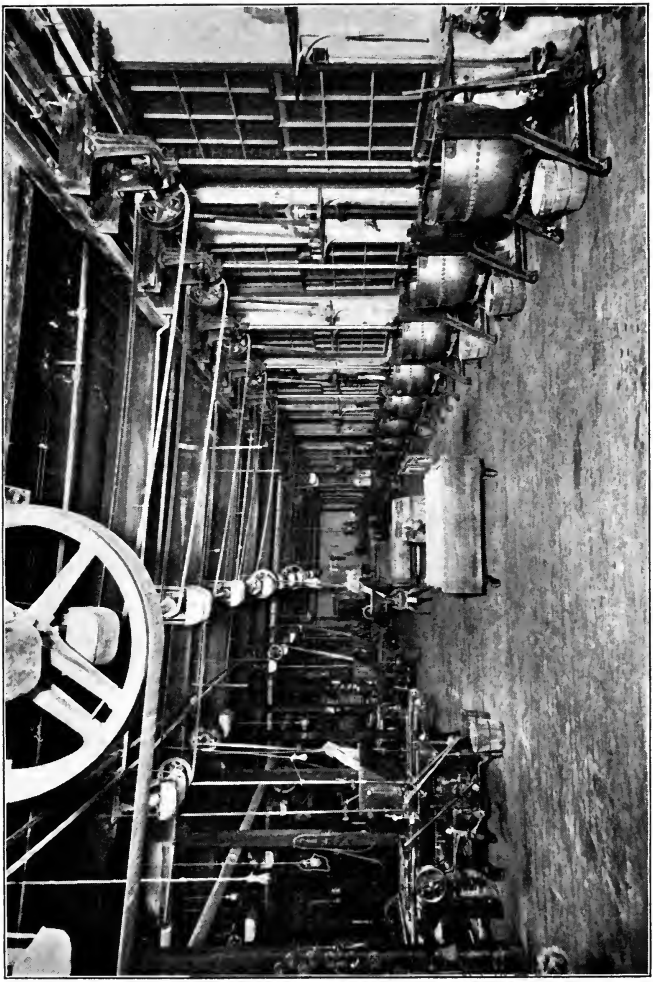

FIG. 28. Cream-Casting Room

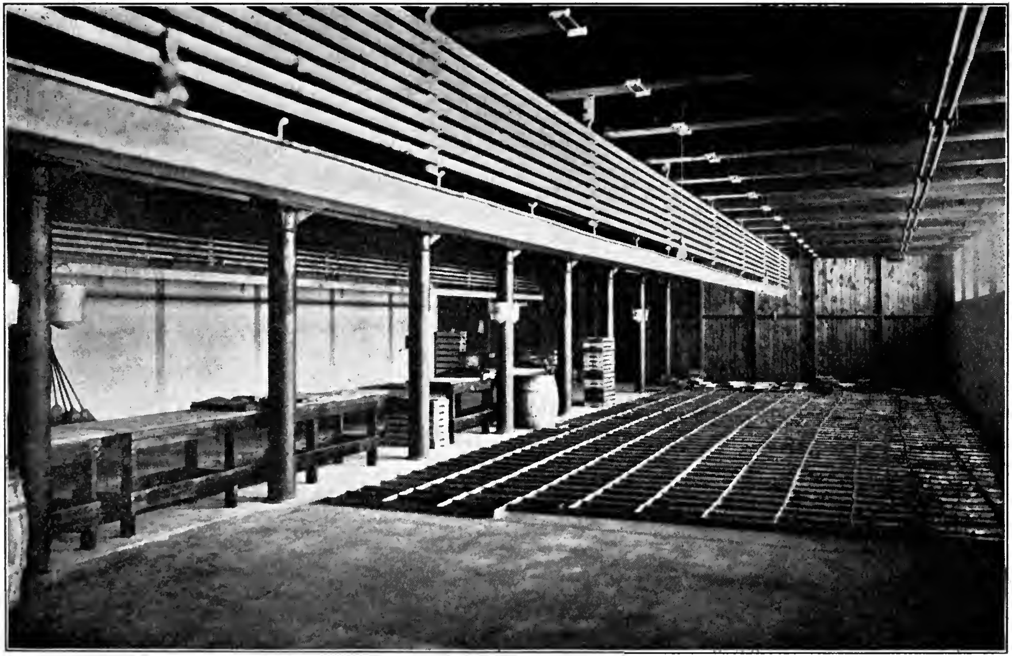

Fig. 29. Cooling Room

There is no attempt at deceit, however, in coloring most candies. Consumers are generally aware that the coloring matter is added merely to please the eye. It is very essential, however, that the dye used shall be absolutely harmless. This question will be discussed in the next chapter.

Flavoring matter of all kinds is also used in large quantities in candies. The same requirement holds good here that the flavoring matter must be wholesome. This subject is fully discussed in Chapter XVIII.

EXPERIMENT

26. Detection of glucose. As glucose contains a considerable amount of dextrin, which is insoluble in methyl alcohol, the presence of glucose in candy and other foods may be tested for in a very simple manner. A concentrated solution of the candy is made by dissolving the sample in two or three times its volume of water. The solution is allowed to settle, or is filtered if insoluble matter is present. On adding methyl alcohol (wood alcohol) with constant stirring, a heavy white precipitate indicates the presence of glucose. Gelatin and soluble starch would also be precipitated by the alcohol.

Sirups, honey, etc., may be examined for the presence of corn sirup in the same manner. The sample is diluted with an equal volume of water and the methyl alcohol added.

CHAPTER XI

ANILINE DYES AND OTHER FOOD COLORS

Fraudulent coloring of foods. The artificial coloring of foods has been very generally regarded as a fraudulent practice. The color and general appearance of many foods is so commonly used as a criterion of quality and condition that any attempt to alter the natural appearance by the introduction of foreign coloring matter at once arouses the suspicion that an attempt is being made to cover defects and to deceive the consumer into thinking that the food in question is better than it actually is. Coloring matter is frequently introduced in order to create the impression that a given constituent is present when it is entirely absent. A common instance of this practice is the use of yellow coloring matter in cakes as a substitute for eggs. Such coloring matter has been sold to bakers under such names as "egg substitute," etc. When, in addition to these obviously fraudulent practices, the fact is taken into consideration that aniline dyes have been very extensively used in foods, and that many of these compounds are extremely poisonous, the opposition to the use of any coloring matter whatever in foods seems fully justified.

Harmless coloring. It has been shown, however, in the chapter on candies, that the introduction of coloring matter into sweetmeats does not deceive the public. In other cases the statement on the label of a food that it has been artificially colored would remove in a large measure the objections to the practice. Of course no coloring matter which is at all poisonous should, under any circumstances, be introduced into foods.

Vegetable colors. Two classes of coloring matter have been used in foods, namely vegetable colors and aniline dyes. The former are obtained by extracting the natural coloring matter from some portion of a given plant. The wood of a number of tropical trees has been largely used for this purpose, such as barbary, Brazil, fustic, Lima, and saffron. In this class is generally included the dye cochineal, which is obtained from a bug which is collected and dried in Mexico and other tropical countries. Butter was formerly often colored on the farm by means of the yellow color extracted from carrots.

The aniline dyes, on the other hand, are produced from compounds which are distilled out of coal tar and combined with various chemical reagents.

Poisonous vegetable colors. While it would seem that the vegetable colors would be more wholesome than the coal-tar dyes, this cannot be assumed, because some of the most violent poisons known are obtained from vegetables. Only when the color is obtained from a vegetable which is known to be wholesome can this be assumed. The vegetable colors lack the brilliancy and high tinting power of the mineral colors, and are also far less permanent, so that in many cases they are destroyed when put into food which is boiled for any length of time. Attempts have been made to render these more permanent by the introduction of mineral constituents such as sulphuric acid. In such processes mineral poisons are liable to be introduced, so that vegetable colors treated in this manner must be considered as partly mineral in character.

Poisonous aniline dyes. Aniline dyes may be poisonous for several reasons, which must be clearly differentiated.

In the first place, the chemical compound which gives the color may be poisonous. On the other hand, if this is harmless, the dye as manufactured and sold may be poisonous, because other poisonous substances introduced in the process of manufacture may not have been entirely eliminated. Among such substances, arsenic is the most common. This element is very widely distributed in the earth, so that it is present in small amount in a great many chemical compounds unless the greatest care has been taken to eliminate it. If such a compound has been used in the manufacture of a given dye, some or all of the arsenic may remain in the dye. For a great many purposes for which aniline dyes are used, the presence of a small amount of arsenic is not objectionable. Dyes which are designed for food purposes must be entirely free from this element. The manufacture of aniline dyes which are entirely free from arsenic requires the very greatest technical skill and care, which tends to greatly increase the cost of such dyes. The color of many dyes is rendered more brilliant or changed in shade if the dye is allowed to combine with a metallic compound. As many of the metals form poisonous compounds, dyes treated in this manner cannot be used for food purposes.

Methods of proving dyes harmless. A great many experiments have been conducted on pure aniline dyes which contained no poisonous impurities, to ascertain if the dye itself is poisonous or harmless. Such experiments have been carried out in various ways. Small animals such as rabbits and dogs have been fed with food containing the dye being tested. The effect on the animals was carefully noted, the dye being fed in varying amounts and for long periods of time, if it proved to be comparatively harmless. In the latter case experiments have been carried out on human beings. In the case of poisonous dyes a record has been made of cases in which such dyes have been taken by human beings by mistake or with suicidal intent. Investigations have also been conducted as to the health of workmen employed in factories where dyes are manufactured. Such workmen are liable to inhale dust containing the dye, or to take food or drink containing small quantities of it.

Experiments with a poisonous dye. The following experiments indicate the character of the evidence obtained in this manner. Experiments with dinitrocresol or saffron substitute resulted as follows: 0.25 gm. was administered to rabbits. The respiration became rapid and the animals soon fell to the ground. Spasms followed, and finally death in from twenty to thirty minutes. Dogs died with similar symptoms from doses as small as 0.1 gm. A woman died in five hours after taking 4.5 gm. of saffron substitute. This dye is clearly a very dangerous poison.

Experiments with a harmless dye. The following experiments were carried out with fuchsin. Two rabbits were fed ½ gm. of the dye in 50 gm. of barley daily for several weeks without showing any bad effects whatever. Other rabbits were fed 15 gm. of the dye in 15 gm. of barley for two weeks without showing any ill effects. One per cent solutions of the dye were injected directly into the blood of rabbits without showing any ill effects. Dogs were fed 20 gm. daily, while a man took 3½ gm. in a week without showing any ill effects. An investigation of the health of 52 workmen employed in a fuchsin factory gave the following results: No ill health could be observed among the workmen, although six had been employed for three to four years, six for four to six years, eleven for six to ten years, and five for eleven to eighteen years. It was concluded from the experiments that fuchsin could be safely employed as a food color.

Dyes permitted by the United States Department of Agriculture. This department has prepared a list[1] of the aniline dyes which have been shown to be absolutely harmless. The use of other aniline dyes in foods is illegal, and the dyes which are allowed must be free from any other coloring matter as well as from any contamination due to imperfect or incomplete manufacture. The use of these dyes is also illegal when the object sought is to conceal damage or inferiority.

Amount of dyes used in food. The amount of dye commonly used in foods is very small, so that only minute amounts are ordinarily consumed by a single individual. One ounce is generally sufficient to color from twenty-five to thirty-five pounds of candy. This accounts for the fact that a relatively small number of cases of serious poisoning have occurred during the many years when manufacturers were under very little restraint as to the dyes which were used.

Harmless vegetable dyes. A number of vegetable colors are in common use and are entirely harmless. Among these are turmeric, cochineal, annatto, indigo, litmus, and saffron.

The tests for aniline and vegetable dyes are given in Chapter XIII.

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[1] Food Inspection Decision 76. The list contains seven dyes as follows: The numbers are given as listed in A. G. Green's edition of the Schultz-Julius Systematic Survey of the Organic Coloring Matters (1904). The list is as follows:

Red shades
107. Amaranth
56. Ponceau 3 R.
517. Erythrosin
Orange shade
85. Orange I.
Yellow shade
4. Naphthol yellow S.
Green shade
435. Light green S. F. yellowish
Blue shade
692. Indigo disulfoacid

This list was prepared for the Department of Agriculture by Dr. Bernhard C. Hesse of New York City, who is an expert on dyes.

CHAPTER XII

PRESERVATION OF FOODS

Modern people well fed. The certainty and regularity with which modern civilized man is supplied with his daily food would have astonished and delighted the people living only a few hundred years ago. Famine can no longer exist except among savages and in semicivilized countries. Civilized man not only expects a bounteous supply of all staple foods, but demands a regular supply of dainties and luxuries at all seasons of the year. No generation has been fed so well as the people of to-day. This certainty of the food supply has rendered it possible for men to give their undivided attention to the development of the arts and sciences, and accounts in no small measure for the remarkable progress made in our industrial life, and for the scientific achievements of the age.

Advantage of methods of preservation. The equal distribution of all kinds of foods during all seasons throughout all parts of civilized countries has been rendered possible by the development of the methods of preservation and transportation of foods. Fresh milk is regularly shipped five hundred miles. Poultry, fish, and meats are kept in cold storage for many months. All kinds of foods have been successfully canned so as to be preserved for years. By the application of hothouse methods of horticulture and rapid transportation from tropical countries, fresh vegetables and fruits may be obtained almost equally well at all seasons of the year. Although, on the whole, man has benefited greatly by modern methods of preservation, it cannot be denied that some harm has resulted from the use of preserved foods, and that some methods which have been used should be condemned.

Methods of preservation in use. The decomposition of foods is almost entirely due to the action of bacteria, as has already been explained in the chapters on milk and bacteria, so that any method of preservation of foods necessarily involves the destruction of the bacteria or arresting their development and growth, or, what is still better, preventing their entrance into food. The methods of preservation of foods which have been used may be grouped into four classes as follows:

1. Desiccation; or drying so as to reduce the percentage of water to a very small amount.

2. Use of low temperature; that is, from 10° C. or 60° F. to considerably below the freezing point.

3. Use of high temperatures; that is, from about 65° C. or 150° F. to considerably above the boiling point of water (about 120° C. or 248° F.).

4. The addition of foreign substances known as preservatives. These may be divided into two groups as follows:

a. Long-used preservatives, — salt, spices, sugar, vinegar, alcohol, smoke, pyroligneous acid.

b. Modern chemical preservatives, — borax or boric acid, sodium benzoate or benzoic acid, sodium salicylate or salicylic acid, formaldehyde, fluorides, sulphurous acid or sulphites, and hydrogen peroxide.

The proper use of each method. All of these methods owe their efficiency as preservatives to their influence on the life and growth of bacteria. We find that these minute organisms cannot grow in the absence of water, at relatively low or high temperatures, nor in the presence of fixed amounts of a considerable number of various substances. It is important to know, with reference to a given method of preservation, not only how the bacteria are affected, but also what changes are produced in the flavor, nutritive value, and digestibility of the food preserved, and also whether the preservative itself is wholesome or not. Careful study will show that all methods of preservation are not equally well adapted to the preservation of a given food. The method chosen must not injure the flavor, digestibility, or appearance of the food. Boiling, for instance, is an excellent method of sterilizing foods for preservation, but it very materially injures the flavor and reduces the digestibility of milk, while, on the other hand, fruits and especially vegetables are in many cases rendered much more palatable and digestible by being cooked.

Preservation by drying. The preservation of foods by drying has been practiced from the earliest times, meats, fish, and fruits being treated in this manner. In hot, dry climates this process has been extensively practiced because no special precautions are needed to insure success. In a cooler climate, especially during damp weather, the food is apt to ferment and decompose before it is sufficiently desiccated. To overcome this difficulty chemical preservatives are often added. In the case of fruits, sulphurous acid is especially suited to this purpose because it preserves the color of the fruit, which would otherwise darken more or less during the process of drying. Recently fruits and vegetables have been dried by subjecting them to the action of artificially dried and heated air. This imitates the conditions found in countries having a hot, dry climate where no preservative is needed. In many ways this is an ideal method of preservation, as the flavor and solubility of many foods are but slightly affected, while such food is easily handled and transported and can be kept in good condition for a very long period of time. Recently such a perishable food as milk has been successfully dried and reduced to a powder, which can be redissolved in water, reproducing the liquid milk.

Sanitary conditions during drying. Recent investigations have shown that sufficient care is not always taken in the drying of fruits to maintain sanitary conditions, and that the exposure of fruits while drying to flies and other insects may lead to the deposition of eggs, which develop into the larvæ of these insects and render the dried fruit unfit for human consumption. Through the rigid inspection by the United States Department of Agriculture fruits prepared under such conditions are being condemned. A careful examination of dried fruits before consumption is always advisable.

Refrigeration. Preservation by refrigeration also has the advantage that no foreign substance is introduced into the food, and only slight, if any, changes brought about in its composition or flavor. It has the advantage over desiccation in that the natural juices remain intact. This method is admirably adapted to the preservation of meat, fish, vegetables, fruits, poultry, eggs, milk, etc. The same temperature is not suitable for all of these foods, and differs with the length of time it is desired to keep a given food. Fruits and vegetables must not be subjected to a freezing temperature, while meats, fish, and poultry can be preserved longer if frozen solid; they must be thawed slowly, otherwise the meat becomes flabby. It is customary, when putting fish in cold storage, to freeze them solid and then dip the fish into cold water, so that a case of ice forms around the fish and remains while it is in cold storage, effectually excluding all contamination. Investigators differ with reference to the length of time meats and other foods may be kept in cold storage without deterioration. Some have concluded that after three months meats begin to lose in flavor and nutritive value, while other investigators have concluded that if a sufficiently low temperature is employed, meats may be kept in good condition for years. As a matter of practice, eggs, poultry, fish, and game are kept from one season to the next; that is, on the average eight or nine months. For financial reasons no large amount of these foods can be held any longer. While the flavor of cold-storage food is somewhat impaired, its nutritive value is unaffected if it has been properly stored.

Sterilization. High temperatures kill bacteria, while low temperatures merely retard or prevent their growth, unless continued for a long time. As has been explained in the chapter on bacteria, these organisms differ in their power to resist high temperatures. A very large proportion are destroyed at a comparatively low temperature. This fact is taken advantage of in the Pasteurization of milk. Such milk will remain sweet for several days. By subjecting the milk or other food product to a temperature somewhat above the boiling point of water, *all* bacteria and their spores are killed. This fact is utilized in the canning of fruits, meats, etc. If the containers of such food are properly sealed, so that no bacteria can gain entrance, the food will remain unchanged for an indefinite time. This method of preservation is ideal for food which requires cooking before being eaten, and is therefore employed very largely with fruits, vegetables, fish, meats, etc. There is some danger that poisons may be introduced into the food from the container. The acids of fruits, for instance, will quite easily dissolve any lead which may be present in the solder, while the tin of the cans largely used as containers is acted upon more slowly. The tin must be pure and the soldering done in such a manner that none of this material comes in contact with the contents of the can. Glass and porcelain are the best materials for the containers.

Preservation by smoking. The fourth method of preservation of foods by means of preservatives has been used from very early times. The use of smoke for the preservation of meat and fish was probably discovered while men lived as savages. It is a very effective method, because smoke contains a very powerful antiseptic known as creosote. This and a number of other substances contained in smoke are highly poisonous, but the amount of these substances which is present in preserved foods is so small that no ill results follow the use of such foods unless they are consumed continuously to the exclusion of other foods. A quick process for producing effects similar to smoking consists in dipping the meat in pyroligneous acid. This liquid is obtained by the dry distillation of wood and may be considered condensed smoke. Meats cured in this manner are not of as fine a flavor as when smoked.

Common salt. This has only slight preservative powers. It hinders the growth of bacteria only when present in fairly large amount, so as to form a fairly strong solution with any liquid present. It must also be considered a food, as it is an essential constituent of the serum of the blood. It is largely used as a seasoning or condiment, especially with vegetables. It is generally eaten in very much larger quantities than necessary to supply the needs of the system. The excess is eliminated largely through the kidneys, requiring considerable labor by these frequently overworked organs.

Vinegar and alcohol. These also have only slight preservative powers, being efficient only when the acetic acid of the vinegar or the alcohol forms a fairly concentrated solution.

Both of these substances are foods because they are oxidized in the system with the liberation of energy. As neither of them can be consumed in more than very moderate quantities, without serious injury, they cannot be used to any great extent for the preservation of foods.

Spices are added to foods mainly to improve the flavor. They assist very materially in digestion by stimulating the flow of the digestive fluids. Most of the spices have also marked preservative powers. Very few foods, however, can be spiced sufficiently to preserve them.

Sugar in concentrated solution almost entirely prevents the growth of bacteria, while in dilute solutions they flourish and grow rapidly. For this reason jams and jellies do not readily spoil, while candies will keep almost indefinitely. As has already been shown, sugar is a highly concentrated food, so that the calorific value of food preserved in this manner is greatly increased and the essential characteristics of the fruits very much changed.

Efficiency of chemical preservatives. The modern chemical preservatives are substances which have very high preservative powers and no food or condimental properties whatever. They have but one function in foods, except in one or two cases where they also serve to increase the natural color somewhat. Their very marked preservative power is evident from the fact that they are generally added to foods in proportions of from 1–50,000 to 1–1000. In even the smaller of these proportions the effect is very marked.

Chemical preservatives tasteless. The most important question in regard to these preservatives is whether they are themselves injurious to health, and whether foods to which they have been added are wholesome. This question is not raised in regard to the long-used preservatives, salt, vinegar, smoke, etc., although some of these contain substances which in concentrated form are violent poisons. The taste of these substances is so pronounced that their presence in foods is instantly detected, and their properties are so well known that there is no necessity of protecting the public by legal enactments. The chemical preservatives, on the other hand, give no evidence whatever by the sense of taste of their presence. Having been used in foods for a comparatively short time, their effect on the human system is not thoroughly understood, while the claim has often been made that they are poisonous and that their use should be prohibited.

The dose of poisons. In attempting to decide this question by experiments on animals and human beings, the fact is frequently overlooked that the quantity of a substance consumed has an important bearing on its effect on the animal organism. Minute doses of the most violent poisons may be taken with little or no effect. As the size of the dose is increased, the effects become more marked until the fatal dose is reached. Large doses are apt to be rejected and therefore not prove fatal. The size of the injurious or fatal dose differs not only with the poison but also with the individual. This personal peculiarity is called idiosyncrasy. In the case of animals this is strikingly illustrated by the fact that chickens can stand ten times and guinea pigs three times as much strychnine as is fatal to rabbits, while dogs can be given enough corrosive sublimate to sterilize the entire digestive tract without fatal results.

Cumulative poisons. While a single minute dose of most poisons can be taken without any noticeable effect, the repeated consumption of small doses of the same poisons leads to serious or even fatal results for two reasons: If the poison is cumulative, it will remain in the system, so that numerous small doses may ultimately produce very much the same effect as a single large dose of the poison. Minute doses of other poisons produce a slight injury to one or more organs of the body. Repeated doses increase the injury, until finally the organ affected breaks down utterly, and serious illness or death results in spite of the marvelous recuperative power of the human system.

Poisons commonly consumed. Human beings have from time immemorial consumed substances which must be classed as poisons. Among these are such well-known substances as alcohol and nicotine (the poisonous principle of tobacco). While the consumption of these substances in large quantities is undoubtedly injurious and may even be fatal, it has been by no means demonstrated that they are injurious when consumed in small quantities. It is well known that adults are far less injuriously affected by these poisons than is the case with the immature. Acetic acid, the active principle of vinegar, is a poison in concentrated form. Muriatic or hydrochloric acid is a poison, and yet it is always present in the stomach and aids digestion. Enough of this acid is produced and poured into the stomach during twenty-four hours to constitute a fatal dose if the total quantity were present at a given moment.

Chemical preservatives are drugs. In studying the substances which are used as preservatives in foods, it is found that all of them may be classed as drugs; that is, they have a specific effect on some function or organ of the human system, so that they are used as medicines. The medicinal dose of these substances varies from 5 to 40 grains, or from $\frac{1}{3}$ to $2\frac{1}{2}$ gm. With some foods enough would not ordinarily be consumed to give this amount, but in other cases a sufficient amount would be taken to produce physiological effects. While a healthy person might not suffer from such promiscuous use of medicines, serious results might be produced with the sick or weak.

Digestion experiments have been carried out in the laboratory with food treated with preservatives and subjected to the action of the digestive ferments, such as pepsin, rennin, amylopsin (pancreatic ferment), and trypsin. The time required for the digestion is generally very much increased, although in some cases the digestion seems to be accelerated. Experiments have been carried out on animals. Dogs, pigs, and rabbits showed no ill effects when fed on food containing borax or boric acid. Young kittens died when fed on milk containing borax, while kittens older than three months were not affected. In some instances where the animal seemed to be entirely healthy, it was killed and its vital organs examined. In many cases the kidneys showed signs of degeneration, due undoubtedly to the fact that most preservatives must be eliminated through these organs. It is somewhat alarming to learn that, while apparently in good health, a vital organ can slowly become diseased from the food eaten.

Experiments on human beings. Very extensive experiments have been carried out on human beings. While a few of these have been conducted on children or invalids, most of them have been carried out on healthy young men. In some of these experiments no ill effects have been noted, while in others, loss of appetite and weight, headache, and nausea have been observed. The most careful and extensive investigations of this kind are being carried out by the Referee Board of the United States Department of Agriculture. Three separate squads of young men have been experimented upon by being fed with food containing benzoate of soda. No evidence of disturbance of the digestion was discovered. The assimilation of the food, as well as the elimination of waste products, was entirely normal. The board concluded that 4 gm. of benzoate of soda per day could be consumed with the food without harm. No experiments on children were conducted by the board. In view of the results of previous experiments, it is quite possible that the immature or aged may suffer from the consumption of a preservative, while vigorous young men might be unaffected. Even though the preservative itself is entirely harmless, foods prepared with it may be unwholesome and inferior to foods prepared without it, so that it might be desirable to prohibit its use.

The action of preservatives toward bacteria is of interest and importance. Among the large number of bacteria which gain entrance into foods, only a few give rise to the disagreeable taste and odors which we associate with decomposing foods. Substances have been selected as food preservatives on account of their ability to preserve the natural taste and odor of foods, and not for their ability to prevent the growth of bacteria in general. Direct experiments upon this point have shown that the action of preservatives on bacteria is selective; that is, the growth of some species is retarded far more than that of other species. The bacteriological examination of preserved and unpreserved foods has shown that when a disagreeable odor and taste begin to appear, the preserved contain a much larger number of bacteria than the unpreserved. In other words, the preservatives prevent the growth of bacteria which produce the foul odors and taste, and allow other bacteria to grow at a rapid rate. In round numbers, the preserved foods can contain about four times as many bacteria as the unpreserved before seeming to be spoiled.

Danger of consuming large numbers of bacteria. A considerable amount of evidence has been produced to show that even in the absence of any specific disease germs, the consumption of foods containing a large number of bacteria increases the death rate. This has been repeatedly shown with public water supplies. If the bacteria content is reduced by filtration or other means, not only is there a reduction in the death rate, due to typhoid and other diseases known to be caused by water-borne bacteria, but the death rate due to other diseases is also materially reduced. The same result has been repeatedly observed with milk. The death rate among children is reduced when milk containing a smaller number of bacteria is used. It would appear, therefore, that the use of preserved food is a menace to public health because such foods may be consumed while swarming with bacteria.

Preservation of decomposed foods. Another very important question is whether the use of preservatives renders it possible for manufacturers to use inferior or decomposed foods. Formaldehyde has been used to a considerable extent to deodorize eggs which were too badly decomposed to be sold. For this purpose the eggs are broken, the shells removed, and the liquid treated with formaldehyde. This practice has been very largely stopped by the health officers. Sulphites have been very largely used in the preparation of sausage meat or Hamburg steak from the trimmings and odd ends which accumulate in the meat shops. These scraps must not be allowed to become too much tainted or the sulphite will not remove the odor. It is very effective, however, in restoring the bright red color to meat which has become dark. On chopping such meat and adding the sulphite a very attractive sausage meat can be produced. Especially when it is exposed to the air the meat acquires a bright red color.

Preservatives *vs.* cleanliness. Taking human nature as it is, it would seem that the use of preservatives would not lead to the adoption of the most sanitary methods of handling foods. Foods could be kept by the aid of preservatives quite as long, even though strict cleanliness were not observed. When we remember that bacteria will grow most luxuriously in the presence of preservatives, the foods handled in this way cannot but be dangerous to health. One of the strongest reasons why the catsup manufacturers desire to use preservatives is that they have been accustomed to handle and keep tomato pulp in bulk until it is convenient to work it up into catsup. The finished product is also sold in barrels to restaurants, where it is put in convenient receptacles for the table until the stock is exhausted. There is no question but that the liability to contamination of the catsup under these conditions is very great. A very thorough overhauling of the process would be necessary if the use of preservatives were prohibited. While benzoate of soda has been found to be harmless in the amounts used in foods when consumed by healthy adults, the evidence at hand with reference to the other chemical preservatives would lead to the conclusion that the consumption of foods containing them is attended with more danger, especially since the most sanitary methods may not have been used in the preparation of the food. It is of the greatest importance that the statement be made on the label of foods that they contain a given preservative, in order that consumers may avoid such foods particularly when in poor health from organic diseases, especially of the kidneys.

Hydrogen peroxide. These general statements about preservatives do not apply to hydrogen peroxide. This compound decomposes very quickly when added to foods. The decomposition products are oxygen and water. The oxygen serves to destroy the bacteria present.

Preservatives do not sterilize foods. The statement has frequently been made that the consumption of foods containing preservatives is accompanied with less risk because the preservative will kill bacteria which are present. This statement is by no means correct, as preservatives are never added in sufficient amount to sterilize foods. In the amount used they simply retard the growth of the bacteria, especially those which produce the disagreeable odor and taste in decomposed foods. So that there can be present in foods containing preservatives a very much greater number of bacteria, before they emit any disagreeable odor or taste, than is possible with foods containing no preservatives. Sterilization with heat, on the other hand, absolutely destroys bacteria which may be present, and is therefore a much safer method of preservation of foods.

CHAPTER XIII

FRUITS, JAMS, AND JELLIES

Composition of fruits. Fruits are composed very largely of water, containing on the average 80 to 90 per cent. Most of the other constituents are held in solution by this water. The solids are composed of sugars, gums, organic acids, starch, a small amount of cellulose, mineral matter, and aromatic substances such as essential oils and compound ethers. A small amount of coloring matter is also present. Chlorophyll gives the green color, xanthophyll the yellow color, and erythrophyll the red. The other shades are produced by a combination of these fundamental colors in varying proportions. With the exception of the mineral matter, all of these substances are carbohydrates; that is, they are composed of carbon, hydrogen, and oxygen. The carbon is obtained from the carbon dioxide of the air, which is decomposed by the plant with the aid of sunlight, giving off free oxygen. The oxygen and hydrogen are obtained mainly from water. The mineral constituents are obtained from the soil, being carried to the plant in solution in water.

Changes in composition during ripening. Fruits in the green state contain a large amount of starch, which is converted into sugar as the fruit ripens. The amount of sugar in some ripe fruits is very large. Grapes may contain as much as 25 to 30 per cent, apples 5 to 15 per cent, and such sweet fruits as peaches and pears almost as much as this. This is another instance in which plants exhibit the ability to change the insoluble carbohydrate, starch, into sugar. Starch is a very convenient and stable form in which the plant can store nourishment for future use. When fruits decay or their juices are allowed to ferment, the sugar undergoes another transformation by which alcohol is produced. In this manner cider and wine are made. The following table shows the transformations which take place during the growth and ripening of apples.

TABLE XXIII

COMPOSITION OF APPLES AT VARIOUS STAGES OF GROWTH

	Very green	Green	Ripe	Overripe	Average for American apples
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Total solids . .	18.47	20.19	19.64	19.74	
Cane sugar . .	1.63	4.05	6.81	5.26	3.40
Invert sugar . .	6.40	6.46	7.70	8.81	7.90
Starch	4.14	3.67	0.17		
Malic acid . .	1.14		0.65	0.48	

This table shows very clearly how the large amount of starch in green apples gradually becomes converted into sugar. Taken in connection with the disappearance of a large portion of the malic acid, the great difference in taste between the green and the ripe apple is accounted for. A similar transformation takes place in the apples which are stored for consumption during the winter. In the fall the apple is hard and tasteless because it contains a large amount of starch. In the spring it is mellow and sweet because the starch has been converted into sugar. The green apple is indigestible because of its large content of starch, which cannot be digested in the raw state. No ill results follow if such apples are cooked before they are eaten, although they still contain a large amount of acid.

The acids found in fruits are quite similar to each other. They are all organic acids, being composed of carbon, hydrogen, and oxygen. They can therefore be oxidized in the human system so as to liberate their energy. Most of these acids are white solids. Besides malic acid, which is found in apples, citric acid found in lemons and oranges, and tartaric acid found in grapes, are typical of this class of substances. Citric and tartaric acids are separated in large quantities for various purposes.

Cream of tartar. Tartaric acid is present in grapes in the form of the acid salt of potassium, which is known as cream of tartar. It is obtained in large quantities in the process of making wine. When the juice is pressed out of the grapes, most of the cream of tartar is present in the expressed juice, while a small portion remains in the solid portion of the grape, known as pomace. When the grape juice is fermented and the sugar converted into alcohol, the cream of tartar crystallizes out because it is insoluble in alcohol. It settles out on the bottom of the wine casks and is known in this crude state as argols or lees. Large quantities of this product are imported from Italy and France and refined in the United States. The cream of tartar is first dissolved in water, the solution filtered and allowed to crystallize. The brown crystals are again dissolved, the impurities precipitated and filtered out, and the solution clarified by filtration through bone black, after which pure white crystals are obtained. These are powdered and used in making baking powder and also sold as cream of tartar.

Tartaric acid. If tartaric acid is desired, the potassium must be removed from the cream of tartar. This is done by the addition of sulphuric or phosphoric acids, which combine with the potassium, after which the tartaric acid may be crystallized out. It is purified by recrystallization in the same manner as the cream of tartar. Both of these compounds are used in the manufacture of baking powder. Cream of tartar has acid properties because it contains only half the amount of potassium necessary to neutralize the tartaric acid.

Citric acid. This acid is prepared from the juice of lemons, the rinds being pressed for their essential oil. By far the greatest quantity is produced in Sicily, and smaller quantities in other localities where the fruit grows abundantly.

Mineral matter. Fruits contain a fairly large amount of mineral matter, as has already been shown. Grapes contain a considerable amount of potassium in combination with tartaric acid. Calcium, iron, aluminium, phosphorus, and manganese are also present in small amounts. These mineral constituents of fruits are in excellent condition for digestion and absorption by the system. *They cannot be absorbed when taken in pure form*, but must first be combined with organic matter. This the plant does in producing the fruit. Inorganic salts of the metals are assimilated only to a slight extent.

Flavor of fruits. The characteristic flavor of fruits is produced by very small quantities of compounds known as compound ethers or ethereal salts. One of the simplest of these is ethyl acetate. It may be easily produced from acetic acid and ordinary alcohol, which is called by chemists ethyl alcohol. By warming these two substances with concentrated sulphuric acid they combine to form ethyl acetate, which may be purified by distillation. It is a colorless mobile liquid of a pleasant fruity odor. Amyl acetate may be produced in a similar manner from amyl alcohol and acetic acid. It is known as banana oil. Its odor is very similar to that of ripe bananas. Amyl valerianate is a compound of amyl alcohol and valerianic acid, and has an odor very similar to that of apples. The odor of few if any fruits is produced by a single substance, but is generally due to the presence of several ethers. Artificial fruit flavors are made by combining several of these compounds, and often resemble in odor very closely the natural fruits.

Pectin. Another constituent of fruits, which causes the juices to solidify into jelly when boiled with sugar, is known as pectin or pectose. It is a carbohydrate and produces a jelly only in the presence of a definite amount of acid, five tenths per cent seeming to be the amount most favorable to the formation of a good jelly.[1]

The following table gives the composition of a number of our common fresh fruits:

TABLE XXIV

COMPOSITION OF FRESH FRUITS

Fruit	Water	Total sugar	Protein	Acid	Ash	Calories
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	
Apples	85.4	11.27	0.64	0.70	0.27	290
Bananas . . .	73.8	21.7	1.17	0.30	0.5	460
Blackberries . .	86.3	10.9	1.3	0.77	0.5	
Cranberries . .	88.9	9.9	0.4	2.34	0.2	215
Grapes	80.12	16.50	1.26	0.59	0.5	450
Huckleberries .	81.9	16.50	0.6		0.3	345
Lemons	88.0	0.37		5.39		205
Oranges . . .	86.0	5.65		1.35		240
Peaches . . .	88.0	10.8	0.7	0.56	0.7	190
Pineapples . .	85.19	12.22	0.48	0.77	0.42	
Plums	78.4	13.25	0.4	1.00	0.52	395
Strawberries .	90.0	7.00	0.9	1.10	0.6	180
Raspberries . .	84.0	12.6	1.7	1.48	0.6	310

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[1] N. E. Goldthwaite, *Jour. of Ind. and Eng. Chem.*, Vol. I, p. 333.

The delicious flavor of most fruits is due to the combination of the sweet taste of the sugars dissolved in the water of the fruit, to which the acid gives an agreeable contrast, and the essential oils and ethers which give the characteristic fruit flavor and aroma. The natural variations in the amount of sugar and acid, as well as essential oils and ethers present in different fruits, are sufficient to suit all tastes and personal idiosyncrasies.

Food values of fruits. It will be observed that bananas have the greatest food value among fruits on account of the large percentage of sugar. Grapes are very nearly as rich in this constituent. While the percentage of protein is apparently small, it is quite appreciable in proportion to the total solids, of which the protein constitutes from 2 to 10 per cent. The fruit acids constitute a still larger proportion of the total solids; that is, from 1 to 45 per cent.

Fresh fruits constitute good summer diet. On account of the small calorific value, a diet of fruits would not be very nourishing unless a very large amount were consumed. For this reason they are admirably adapted to be the food of people living in tropical countries, and as a summer diet when a high calorific value is unnecessary. The acid present in fruit is also desirable during the summer, although in some cases it acts injuriously. In eating raw fruits there is some danger from bacteria adhering to the surface, especially when the fruit has been exposed for sale on a dusty street.

Preserved fruits constitute good winter diet. While fresh fruits form a most desirable food for the summer, preserved fruits, especially jams and jellies, are well adapted for consumption during the winter, on account of the high calorific value produced by the large amount of sugar which has been added, constituting generally at least 50 per cent of the preserved fruit. The calorific value of dried fruits is also higher than that of fresh fruits because most of the water has been expelled.

Cold storage of fruits. As has already been stated, every method of preservation must kill the bacteria present or retard their growth and activity. Cold storage is well adapted to the preservation of fruits, provided the temperature is not allowed to fall below the freezing point. Many fruits may be kept in excellent condition by this method for six to nine months, so as to be quite as palatable as the fresh fruits.

Dried fruits. Preservation of fruits by drying has been practiced for centuries. Until recently very little improvement has been made over the primitive method of drying in the sun. The modern preservatives have been used to prevent the formation of mold during the drying process. Sulphurous acid has been most largely used, because the fruit containing it does not darken during the drying process. The fresh fruit is exposed to the fumes of burning sulphur before being placed on the drying frames. While some of the sulphurous acid escapes with the moisture, a considerable amount always remains and is consumed with the fruit. In this manner the so-called evaporated apples are produced, which are perfectly white, without a trace of darkening.

Desiccated fruits. The necessity of using preservatives is entirely obviated when a method of drying, recently devised, is employed. Air which has been artificially deprived of its moisture and then heated is passed over the fruit. The moisture is taken out so rapidly that molds and bacteria cannot grow. The dried fruit may be kept indefinitely without decomposition. On moistening with water the fruit regains its flavor and bulk. This method of drying is superior in many ways to the older processes.

Canned fruits. Preservation by means of heat involves cooking the fruit. In some cases this is an advantage because the fruit is made more digestible. This method cannot be used with some fruits because the flavor is destroyed by cooking. In all cases, after sterilization, the entrance of bacteria must be prevented. This is generally accomplished by sealing in an air-tight container. The exclusion of the air is not essential to the preservation of the fruit. It would keep quite as well if placed in a bottle closed with a plug of cotton. The cotton keeps out bacteria, because the latter are found on particles of dust which are sifted out by the cotton.

Jams and jellies. Fruits are also preserved by boiling with sugar. If the whole fruit is used, jam is produced. As most of the nutriment of fruits is in solution in the juices, the composition of jams and jellies is very similar. The portion discarded in making jelly is quite indigestible. The following table gives the composition of jams and jellies:

TABLE XXV

Composition of Jams

Fruit	Solids	Reducing sugar	Cane sugar	Total sugar	Acid	Protein	Ash
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Apple . . .	63.22	25.52	29.11	54.63	0.28	0.18	0.20
Blackberry .	55.42	18.77	29.00	47.77	0.85	0.74	0.48
Grape . . .	56.64	33.44	11.33	44.77	0.74	0.53	0.74
Pear . . .	61.52	13.20	33.74	46.94	0.16	0.31	0.28
Peach . . .	65.65	36.48	23.16	59.64	0.5		
Plum . . .	50.43	28.29	9.70	38.00	1.01	0.53	0.54
Pineapple .	73.92	14.05	46.40	60.45	0.32	0.31	0.30

TABLE XXVI

Composition of Jellies

Fruit	Total solids	Reducing sugar	Cane sugar	Total sugar	Acid	Protein	Ash
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Apple . . .	59.18	20.78	33.04	53.82	0.28	0.18	0.22
Blackberry .	59.63	12.51	44.90	57.41	0.48	0.24	0.33
Crab apple .	63.28	34.93	23.68	58.61	0.17	0.14	0.11
Grape . . .	63.66	32.29	30.52	62.81	0.52	0.18	0.45
Huckleberry	63.02	24.27	32.74	57.01	0.25	0.07	0.28
Orange . .	68.56	3.95	62.52	65.47	0.17	0.42	0.30
Peach . . .	69.98	8.75	56.59	65.34	0.25	0.18	0.21
Pear . . .	69.12	6.58	58.46	65.04	0.18	0.16	0.34
Pineapple .	80.28	22.13	56.70	78.83	0.33	0.39	0.43
Plum . . .	45.56	19.18	22.67	41.85	1.13	0.35	0.68
Mixed fruit .	66.58	39.17	24.22	63.39	0.37	0.07	0.21

Food value of jams and jellies. The amount of sugar in these foods is about 50 per cent. Only a portion of it is present as cane sugar, because a considerable portion of the sugar added has been hydrolyzed by the acid of the fruit during the boiling. A portion of the reducing sugar is that naturally present in the ripe fruit. As the percentage of total solids is very large, these foods are very concentrated and can give a large amount of energy. The fruit flavor, acid, and color make them very palatable foods.

Jelly making. Jellies are characterized by a peculiar consistency, which may be described as a solid of very slight strength. While the jelly retains the shape of the mold in which it is cooled, it can hardly support its own weight. The constituents of fruits which cause them to "jell" are pectin and acid. Almost all fruits contain the requisite amount of pectin, but many of the sweet fruits, such as peaches, blackberries, pears, etc., contain too little acid.

For this reason, jelly may be made from these fruits if they are used before they are fully ripe. The fruit juice must contain about ½ per cent of acid and 1 per cent of pectin. As most fruits contain a sufficient amount of pectin, failure to obtain a jelly is generally due to the absence of the requisite amount of acid. This may be introduced by adding tartaric acid, or, what is perhaps more satisfactory, the juice of a strongly acid fruit may be mixed with that of a sweet fruit. The fruit juice must be boiled with the sugar long enough to hydrolyze a portion of the latter, but not long enough to convert all of the cane sugar into reducing sugars. The proper conditions are reached when the boiling point is about 103° C. and the specific gravity of the hot mixture is 1.28.[1] The proper proportion of sugar is also important and varies slightly with different fruits. All bacteria are killed during the boiling of the jelly. By pouring melted paraffin over the solidified jelly the entrance of more bacteria is effectually prevented. The growth of any bacteria which may gain entrance is very slow in the highly concentrated sugar solution.

Artificial jellies. It has been assumed in the preceding discussion that fruit juice and sugar are the only constituents necessary for the preparation of jams and jellies. As made in the household, this is true. The food market has been flooded with jams and jellies which have been manufactured in large quantities by very different methods. Instead of the various fruit juices, apple juice, together with an artificial flavor and color, has been substituted. The apple juice would give the necessary pectin, while the added color and flavoring matter would suggest the fruit whose jelly was imitated. In some cases the fruit flavor is obtained by using apple juice mixed with a small quantity

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[1] N. E. Goldthwaite, *Jour. of Ind. and Eng. Chem.*, Vol. I, p. 333.

of the fruit whose flavor is desired. A cheaper jelly is obtained by using gelatin without any fruit juice at all, even that of the apple being omitted. The slightly acid taste of fruit jellies is obtained by the addition of organic acids, such as tartaric and citric; although at times mineral acids, such as sulphuric or muriatic, have been employed. In such artificial jellies glucose has been largely used in place of sugar, the sweet taste being given by saccharin. Artificial coloring and flavoring matter complete the deception. That the consuming public can be easily deceived is shown by the fact that large quantities of such artificial jelly has been sold under a variety of labels, such as currant, raspberry, strawberry, etc., while the contents of the jars was identical in every respect, no attempt being made to vary the color or flavor.

Wholesomeness of artificial jellies. These artificial jellies have generally contained no injurious constituents except the mineral acids and poisonous coal-tar dyes or artificial flavors. The apple juice, glucose, and gelatin are substances of recognized food value. The fraud practiced on the public is largely one of deception. The protection afforded by pure-food laws has been the exclusion of poisonous constituents and the prohibition of the use of deceptive labels, making it illegal to sell as a fruit jelly a compound of gelatin, glucose, aniline dye, and artificial flavoring matter. If the ingredients are wholesome foods, a label stating the contents of the compound is a sufficient protection to the purchaser.

Adulterated jams. In a similar manner, jams are considered to be a product made by boiling fruits with sugar. A common practice with dishonest manufacturers has been to make jams out of the fruit pulp from which the juice has been expressed for the purpose of making jelly. By cooking with sugar or glucose, and, if necessary, adding an acid, coloring matter, and artificial flavoring matter, a product would be obtained which could with difficulty be distinguished, without a chemical analysis, from genuine jam. Most of these jams, as well as the artificial jellies, would be preserved with a chemical preservative as a cheaper method than careful sterilization and sealing of the jars.

EXPERIMENTS

27. Testing fruits for starch. Test green fruits, such as apples, pears, bananas, etc., for starch by applying a few drops of iodine solution to the freshly cut surface. If the blue color does not develop, scrape off a little of the fruit with a knife and treat with boiling water. Allow to cool and repeat the test. Repeat the test with ripe fruit.

28. Testing fruits for pectin. Prepare samples of the juices of both green and ripe fruits of various kinds, such as apple, peach, currant, etc. The fruit should first be crushed, then warmed and strained through cloth. Place 5 ccm. of each sample in a test tube, add an equal volume of alcohol, shake, and allow to stand. The gelatinous precipitate which settles out in each case is the pectin of the fruit. A considerable difference in amount and character of the precipitate will be noticed.

29. Acidity of fruit juices. The acidity of the fruit juices prepared in Experiment 28 is determined in the following manner: A small portion of the fruit juice is diluted with ten times its volume of distilled water, and, while stirring, a dilute solution of caustic soda (see Experiment 14) is added drop by drop until a decided change of color is noted. By testing with red and blue litmus paper it will be found that at the point when the solution changes from acid to alkaline a decided change of color occurs. The litmus paper is dyed with a vegetable color, which is red in acid solution and blue in alkaline solution. A large number of other vegetables contain coloring matter, which undergoes a decided change when the acid present is neutralized with a base.

Having noted the change in color at the point where all the acid is neutralized, measure out exactly 10 ccm. of the fruit juice, dilute with 100 ccm. of distilled water, and titrate with fifth-normal or tenth-normal caustic soda solution (see Experiment 14) until the color change is observed. Calculate the per cent of acid present. For this purpose 1 ccm. of fifth-normal caustic soda is equal to 0.01 gm. of acid. If 5 ccm. of soda were used for 10 ccm. of the juice, the per cent of acid would be five tenths $\left(\frac{5 \times 0.01 \times 100}{10} = 0.5\right)$.

As some fruit juices contain very little natural color, it will be necessary to use litmus or some other indicator to ascertain when enough caustic soda solution has been added. Litmus paper may be used or a solution of the dye, or, still better, a solution of methyl orange. This indicator is prepared by dissolving $\frac{1}{10}$ gm. of the dye in 100 ccm. of water. Only a few drops of this indicator should be added to the solution of the fruit juices.

When the acidity of the fruit juices has been ascertained, experiments may be carried out to determine the jelly-making properties of the juice. The nature and amount of the pectin present will also be found to be of importance for this purpose. Equal portions of the juice and sugar are boiled and set aside to cool. If the acidity of the juice is high, a portion of the acid may be neutralized by the addition of measured volumes of the caustic soda solution, while if the juice is deficient in acid, citric, malic, or tartaric acid, or some strongly acid fruit juice, may be added. Experiments may also be made by varying the proportions of sugar and juice.

30. Testing for fruit juices. The colors obtained when the acid of various fruit juices is neutralized are quite different, and characteristic with different fruits. A considerable amount of organic matter is also present in fruit juices, which is precipitated with lead acetate and can be used to identify natural fruit juices. A solution of basic lead acetate has been found to combine the alkalinity with the soluble lead necessary to give both of these reactions. The solution is made as follows: 18 gm. of lead acetate are dissolved in 70 ccm. of hot distilled water and 11 gm. of lead oxide added. The mixture is boiled for half an hour with occasional stirring, after which it is allowed to settle for a few minutes and is then filtered. Enough distilled water is added to make the volume about 81 ccm. The solution must be kept in well-stoppered bottles. A dilute solution made by adding about four volumes of water to one volume of the strong solution will be found suitable for the following tests:

Place equal portions of the fruit juices prepared in Experiment 28 in test tubes and add the lead subacetate solution until no further precipitate or change in color is produced. Note carefully the color changes and character of the precipitates obtained from these pure fruit juices.

Test commercial samples of jams and jellies as follows: Add equal volumes of water, warm, and stir until a homogeneous solution is obtained, and filter. Test the filtrates with the lead subacetate solution.

31. Testing for aniline dyes. As most artificial jams, jellies, and other fruit products are colored with aniline dyes to imitate the natural product, the test for the dyes gives good evidence of the character of the products. The test is carried out as follows: White woolen cloth is cut into narrow strips and freed from grease by boiling in very dilute caustic soda solution for about ten minutes. The soda is then washed out by boiling in water. The cloth is then dried and preserved for use.

About 15 gm. of the fruit product are dissolved in 100 ccm. of distilled water, and then filtered if necessary. A few drops of dilute hydrochloric acid are added, and the solution again filtered if necessary. Strips of the woolen cloth are placed in the solution, which is boiled for five to ten minutes. The cloth is removed and washed in water and boiled in very dilute hydrochloric acid. The coloring matter naturally present in fruits generally imparts a dull color to the cloth, while aniline dyes produce bright shades.

As a further test the color is dissolved by boiling the cloth in a dilute solution of ammonia made by adding a few drops of strong ammonia to 25 ccm. of water. When no more solvent action is observed, the cloth is removed, the solution is made acid, and a fresh piece of woolen cloth boiled in the solution. If the second piece of woolen cloth is dyed, aniline dyes are present.

Frequently with whole fruit like cherries the coloring matter is present in the solid particularly. When this is the case, the liquor should be drained off and the finely divided fruit warmed with three times its bulk of alcohol until the color is sufficiently extracted. The mixture is then filtered, and after diluting the filtrate with twice the volume of water and acidifying with hydrochloric acid, the wool is dyed as already directed.

CHAPTER XIV

FRESH AND CANNED VEGETABLES

Composition of vegetables. Vegetables are very similar in composition to fruits. They contain about the same percentage of water and solids and have the same calorific or energy value. They differ from fruits in that the main constituent is starch, while sugar is the most important constituent of fruits. For this reason, vegetables must, as a general rule, be cooked before being eaten, while ripe fruit may be eaten raw. If vegetables are baked, the starch is to a greater or less extent converted into sugar, giving a sweeter taste. Vegetables are more easily stored and kept in good condition because starch is a very stable substance. If they are allowed to sprout, however, the starch is rapidly converted into sugar and the vegetable soon decays. Vegetables also differ from fruits in containing little or no acid, but decidedly more mineral matter. The table on page 156 gives the composition of a number of common vegetables.

Water in vegetables. In spite of its name, watermelon does not contain the largest percentage of water. Asparagus, lettuce, celery, and pumpkins contain a larger percentage, while cucumbers contain the largest amount of this constituent. Corn, peas, and potatoes contain the least proportion of water, and therefore are the most nourishing of vegetables.

Adulteration of vegetables. There is very little opportunity for fraud or adulteration in the sale of vegetables, as

TABLE XXVII

COMPOSITION OF VEGETABLES

Vegetable	Water	Starch	Sugar	Protein	Ash	Calories
	Per cent	Per cent	Per cent	Per cent	Per cent	
Asparagus	93.6	2.55		1.83	0.67	105
Beans	87.23	7.52		2.20	0.76	195
Beets	88.47	7.94		1.53	1.04	215
Cabbage	90.52	3.85		2.39	1.42	145
Carrot	88.59	7.56		1.14	1.02	210
Celery	94.50	3.5		1.25	0.60	85
Corn	73.00	13.50	6.00	5.00	0.70	470
Cucumber	95.09	1.83		0.81	0.46	85
Lettuce	93.63	2.18		1.41	1.61	90
Onion	87.55	9.53		1.40	0.57	225
Parsnip	80.34	16.09		1.35	1.03	300
Peas	79.93	13.30		3.87	0.78	465
Potatoes, Irish	75.00	19.87	0.77	2.00	1.00	400
sweet	70.27	24.00	6.81	2.41	1.14	570
Pumpkins	93.39	3.93		0.91	0.67	125
Watermelon	91.87	6.65		0.40	0.33	150

they are generally sold in their natural state. Canned vegetables may contain deleterious ingredients. Canned asparagus and mushrooms are frequently bleached by means of sulphurous acid. The green color of canned peas, etc. is frequently preserved with copper sulphate. As this is a violent poison, only minute quantities can be taken with foods without danger. The sale of foods containing this coloring matter is permitted if the amount present is not excessive and its presence is stated on the label.

Desiccated vegetables. It is possible, by means of recently improved methods of drying, to produce desiccated vegetables, which, when soaked in water, regain the taste and other properties of fresh vegetables. If kept in a dry place, such desiccated vegetables will keep indefinitely, and can readily be transported, as they are very light on account of the absence of the large amount of water present in their natural condition.

Catsup. This is a sauce made from tomatoes and various spices. A great variety of substances have been used in making some of the catsups which have been placed on the market. Turnips and other cheaper vegetables and corn meal have been substituted for the tomatoes, the red color being obtained by the addition of aniline dyes. When tomatoes have been used, they have commonly been preserved with sodium benzoate or other preservatives. Inferior or old tomatoes could be utilized by the addition of the preservative. Before the recent national Pure Food Law was enacted, practically all of the catsup sold contained a preservative. Since then methods have been developed for the preparation and marketing of tomato catsup without a preservative, sterilization by means of heat being substituted. Such catsup cannot be sold in bulk, but must be put up in bottles and must be used within a short time of opening the bottle.

EXPERIMENTS

32. Testing for sulphur dioxide. Test canned asparagus, mushrooms, or other light-colored canned vegetables for sulphur dioxide by the methods given in Experiment 21.

33. Testing for copper sulphate. Canned peas, beans, or spinach may be tested for the presence of copper sulphate as follows: A few cubic centimeters of the liquid portion are acidified with hydrochloric acid and filtered. To the clear solution a few drops of barium chloride solution are added. A white, finely divided precipitate, which settles slowly, indicates the presence of sulphuric acid, formed by the decomposition of copper sulphate. This test will frequently fail with all except spinach, because the vegetables have generally merely been dipped in a copper sulphate solution and then drained.

From 25 to 50 gm. of the solid portion of the canned vegetable are placed in a porcelain or platinum dish and heated gently. After the moisture has been expelled the heat is increased until the material begins to burn. When only charcoal remains, the dish is allowed to cool and the residue is moistened with not more than 3 ccm. of concentrated nitric acid and warmed for a few minutes. After adding 25 to 50 ccm. of water the charred mass is well stirred and filtered. If copper sulphate has been used, the copper will be present in the nitric acid solution. A portion of the solution is neutralized with ammonia and a slight excess added. If copper is present, the solution will be blue. After observing the color, acetic acid is added until the solution is again acid, and a few drops of potassium ferrocyanide solution are then added. A wine-red color indicates copper.

The copper in the remainder of the nitric acid solution may be plated on platinum foil as follows: A few cubic centimeters of dilute sulphuric acid are added and a small piece of platinum foil is suspended by a platinum wire in the solution. Another platinum wire or foil is suspended in the solution, care being taken that it does not touch the first piece of platinum. The two wires are connected with an electric circuit in such a way that the platinum foil is attached to the negative wire of the circuit. Electric batteries or a direct electric-lighting circuit may be used. In a few hours the copper will be deposited on the platinum foil and may be easily seen by its red color.

If all the nitric acid solution from a weighed amount of the canned vegetable is used, and the platinum foil is weighed before and after the copper is deposited, the amount of copper or copper sulphate in the vegetables may be ascertained. By multiplying the weight of copper obtained by 4, the weight of copper sulphate will be obtained. Although the copper was added as copper sulphate, it is not present as such in the vegetable, but is combined with the organic matter, presumably with the protein. For further details on making the determination, the author's textbook, "Quantitative Chemical Analysis," may be consulted.

34. Testing for aniline dyes. Canned tomatoes or other canned vegetables which are suspected to have been colored with aniline dyes may be tested by the method given in Experiment 31.

CHAPTER XV

BREAD AND THE CEREALS

Bread an ideal food. In many ways bread is an ideal food. It contains all the elements necessary to sustain life, although it is somewhat deficient in fat. For this reason it is generally eaten with butter or other food rich in fat. The physical form of bread is such that with proper mastication the digestive fluids readily penetrate the mass. It does not digest rapidly, but gradually, and thus meets the needs of the system for nourishment, without the necessity of eating frequently. Bread is classed as a staple food because it can be consumed by all human beings without any ill effects. An exclusive diet of bread would, of course, become very distasteful, as the needs of the human system seem to be best met by a mixed and varied diet.

Gluten. Bread can be best made only from wheat and rye flour, on account of the peculiar property of the gluten or protein of these grains. It has the property of absorbing nearly three times its weight of water and forming a viscous, sticky, tough, and elastic mass. The carbon dioxide gas produced by the action of yeast distends this elastic mass, which hardens during the baking and leaves the bread light and porous. As corn and other cereals cannot form such an elastic mass, they cannot be used for making bread. Wheat and rye contain a large percentage of protein, namely 10 to 14 per cent, while Indian corn, barley, and buckwheat contain only from 7 to 9 per cent. As the nitrogenous constituent of foods is the most difficult to produce and the most expensive, this larger percentage of protein in wheat gives it a decidedly greater value as a food.

The following table gives the average composition of wheat flour:

TABLE XXVIII

Composition of Wheat Flour

	Per cent
Protein or gluten	10–13
Starch	75
Fat	1–1½
Ash or mineral matter	½–1
Water	10–12

Grades of flour. The relative amounts of protein and starch vary with the kind of wheat and the soil and climate in which the wheat is grown. The protein and starch are also unequally distributed in the grain, the percentage of protein being greatest near the hull and least in the center, where the percentage of starch is greatest. The various grades of flour on the market differ in composition not only because made from different grades of wheat, but also because made from different portions of the kernel of the wheat. The patent or middlings flour, which constitutes by far the largest part of the flour produced, contains less protein and ash and more starch than bakers' or family flour, of which only about one fourth as much is produced. The hulls of the grain constitute the bran, which contains 0.8 per cent of mineral matter and as high as 15 per cent of protein, and is used as cattle food.

Graham and whole-wheat flour. These flours contain the entire kernel of the wheat, and by bolting could be separated into bran, patent, and family flour. The percentage of ash or mineral matter, as well as protein, is therefore considerably higher than in the finer or bolted grades of flour. For this reason the claim has often been made that whole-wheat and Graham bread constitute a more nutritious diet than bread made from bolted flour. Careful dietary experiments have proved this idea to be erroneous. It has been shown that the system is unable to assimilate as large a proportion of the mineral and protein matter of whole-wheat flour as of the finer grades, so that from a given weight of bread the same amount of nourishment can be derived, whether made of bolted or unbolted flour. In addition it appears that the coarser particles of bran in the whole-wheat flour have an irritating effect in many cases on the delicate lining of the digestive tract.

Bleached flour. Wheat flour is subject to some adulteration. Inferior grades of wheat flour are at times mixed with or sold as superior grades. This practice has become more common since the processes of bleaching flour have been introduced. The grade or quality of flour is largely determined by its appearance, odor, and color, as well as by its fineness, as indicated by rubbing between the fingers. A very minute amount of nitric oxide will remove the yellow tint of an inferior grade of flour, so that it can be sold as a much higher grade. The sale of bleached flour is therefore generally held to be illegal. The bread-making qualities of a sample of flour may be ascertained by a test of the tenacity and elasticity of the dough produced from the flour. This is an important test in the hands of an experienced person.

Mixed flour. Flour made from other grains is sometimes mixed with wheat flour. Corn and barley flour have been used as adulterants in this manner. These foreign flours are detected by a microscopic examination. The starch grains of wheat are circular and of two sizes, the larger having a diameter of 0.021 to 0.041 mm. and are marked with concentric rings, while the smaller grains have a diameter of about 0.005 mm. The starch grains of the other cereals are of a different size and appearance.

Other flours than wheat. Flour made from other grains than wheat is less used and differs in composition from wheat flour to a considerable extent. Rye flour contains a larger percentage of protein, ash, and crude fiber than wheat flour. It is also much coarser and makes a darker-colored bread. Indian corn flour contains only about 7 per cent of protein and a higher content of starch and fat than wheat flour. The protein does not form the tough elastic mass so characteristic of the gluten of wheat flour. Barley flour is similar in composition to corn flour but contains less fat. Buckwheat flour contains a relatively large amount of fat and has only a small percentage of protein.

The raising of bread. Bread is any baked mixture of any kind of flour and water with or without a leavening agent. By bread is generally understood that made from wheat or rye flour. While at times the dough is raised by a chemical substance, such as baking powder, the great bulk of the bread used is raised by means of yeast. Chemically the bread produced by means of yeast is slightly different from that raised by means of baking powder. A small percentage of soluble carbohydrates is present in flour and dough. The yeast acts on this material, converting it into alcohol and carbon dioxide gas, which becomes entangled in the gluten and, by expanding when heated, raises the bread. Although a portion of the alcohol escapes during the baking, fresh bread contains a small amount of alcohol. Baking powder does not bring about any decomposition of this kind. During the process of baking, a small percentage of the starch is rendered soluble by being converted into dextrin and invert sugar, which gives a slightly sweet taste to the bread, especially the crust.

Water in bread. A common method of making cheap bread consists in introducing more than the normal amount of water. Well-made bread should contain from 33 to 40 per cent of water. A poor quality of bread will contain from 40 to 48 per cent of water. Bread containing this amount of water tends to become moldy. Another common method of defrauding the customer consists in selling light-weight loaves. The loaves on the market differ very much in weight, many of them being lighter than the standard pound weight.

Adulteration of bread. Aside from adding too much water, using an inferior grade of flour, and making light-weight loaves, other adulterations of bread are rarely practiced. Gypsum, chalk, bone ash, and other minerals cannot be added to bread without visibly affecting its quality. The use of alum to improve the appearance of bread made from inferior flour is not very common. Sulphate of copper has also been used to a limited extent for the same purpose.

Adulteration of cake. Cake differs from bread chiefly in the addition of eggs, sugar, butter, spices, and flavoring matter. Some of these ingredients are subject to considerable adulteration, while frequently very inferior grades are used in cake because the consumer has no means of judging the quality of the ingredients. Owing to the cost and difficulty of obtaining fresh eggs, the temptation is very great to use some form of preserved eggs. No objection can be raised to the use of cold-storage eggs in good condition, or a good grade of desiccated eggs. This cannot be said of the liquid eggs which have been used to a considerable extent. Such eggs have been broken and the liquid portion separated from the shells. By the addition of a preservative, such as borax or formaldehyde, such eggs could be transported in open casks from China to New York. Eggs which have become so badly decomposed as to be unsalable could be rendered odorless by the addition of formaldehyde. Through the activity of the state and national health authorities the sale of such eggs has been largely prevented.

Egg substitute. The addition of the requisite number of eggs for a given cake is often entirely omitted and their absence masked by the addition of the requisite amount of some coloring matter. If a portion only of the eggs is omitted, enough coloring matter is added to give the color produced by the full number of eggs. This deception is possible because the consumer considers the yellow color evidence of the presence of eggs. Such yellow coloring is often sold under the name of "egg substitute."

Breakfast foods. The cereals are also consumed in large quantities in the form of breakfast foods. They differ very little in composition from the cereal from which they are made. By various processes, such as steaming, roasting, or baking, the starch of the cereal is rendered more soluble and partially converted into sugar, so that the flavor is improved and the time required for cooking the breakfast food is materially reduced or cooking rendered entirely unnecessary. Individuality is also given to the various preparations by varying the size and general appearance of the grains.

CHAPTER XVI

LEAVENING AGENTS

Discovery of yeast. Bread is undoubtedly one of the foods which has been used for the longest time by man. In the most primitive state of civilization cereals of various kinds were crushed by means of flat stones or crude mills. The flour so made was mixed with water and baked on hot stoves into cakes. It was very early discovered that cakes which were allowed to remain for some time before baking were more porous and palatable, and that this object was still better attained by reserving a portion of one day's mixing to be kneaded into the fresh cake of the following day.

The yeast plant. Although this process of leavening is of the greatest antiquity, it is less than a century since the nature of the process was at all understood. It is now known that leavened bread contains an enormous number of microscopic organisms known as the yeast germ or plant. When this plant grows and multiplies, it converts certain soluble carbohydrates into alcohol and carbon dioxide. This carbon dioxide gas remains entangled in the dough, so that when heat is applied it expands and causes the bread to rise. A common household method of making bread lighter consists in adding to the dough the water in which potatoes have been boiled. This method is effective because this water contains dissolved starch, which is acted upon by the yeast with the production of carbon dioxide. The same object is attained by the addition of a form of dextrose known as bakers' sugar. This is manufactured from cornstarch and is largely used by the bakers.

Sour bread. If the dough is allowed to stand for too long a time or at an unsuitable temperature, another so-called ferment may become active and convert the alcohol into acetic acid, thus making the dough sour. We know now that the germs of these organisms are widely distributed in nature, so that, unless the greatest care is taken to exclude them, they will be present and set up fermentation in any suitable organic matter. It is for this reason that most foods rapidly become sour, especially during warm weather.

Raising bread by means of carbon dioxide gas. Since the nature of the process of raising bread was made clear, many attempts have been made to supplant the old-fashioned method of raising bread by means of yeast, but so far these efforts have met with very little success. As bread is raised by the expansion of the imprisoned carbon dioxide gas, the attempt has been made to force this gas into the dough, which for this purpose was placed in steel cylinders. An attempt in London to sell bread made by this process did not succeed, because the bread differed in flavor from that raised with yeast.

Liebig's method of raising bread. Attempts have been made to mix with the flour chemical substances which would gradually liberate the carbon dioxide gas necessary to raise the bread. The distinguished chemist Liebig suggested that a very suitable combination of this kind would be sodium bicarbonate and hydrochloric (muriatic) acid. By the interaction of these substances the carbon dioxide needed would be liberated, and there would also be formed some sodium chloride or common salt, which would be necessary in any case for the purpose of seasoning the bread. The difficulty in using this process is that it would be necessary to have an acid of exact strength, and to measure the acid as well as the sodium bicarbonate with the greatest care, so that an excess of neither substance would be present. The ordinary cook or baker does not possess the intelligence and skill necessary to do this.

Cream of tartar baking powders. A number of other acids have been more largely used, sodium bicarbonate being in each case the substance employed to furnish the carbon dioxide gas. Acid potassium tartrate or cream of tartar has been quite largely used. Formerly these two substances were purchased separately and the proper quantities of each measured out and added to the flour before mixing the dough, the sodium bicarbonate being known as saleratus. The use of these substances separately has now been very largely superseded by the so-called baking powders. These powders are simply mixtures of sodium bicarbonate and a solid acid constituent like potassium bitartrate. When such a mixture is moistened with water, the acid acts on the bicarbonate of soda, liberating carbon dioxide and forming the sodium salt of the acid constituent. As the moisture of the air is slowly absorbed by the mixture, the baking powder would slowly lose its carbon dioxide and be reduced in strength. In order to prevent this action, starch must be added to the mixture.

Alum and phosphate baking powders. A number of other acid substances are used in baking powders, the most common being acid calcium phosphate and alum. Sodium bicarbonate must always be present, as well as starch, to prevent interaction between the constituents of the powder until it is moistened in the process of mixing the batter. The three classes of baking powder are known as tartrate, phosphate, and alum powders. They are about equally efficient as leavening agents, the constituents being combined in such proportions that they exactly neutralize each other. Starch is added in a proportion sufficient to give powders of equivalent strength, so that a teaspoonful of any baking powder shall liberate the same amount of carbon dioxide. The various powders on the market differ somewhat in keeping qualities and also in the relative rapidity with which the carbon dioxide is liberated. These properties may be somewhat modified by adding a small amount of tartaric acid to the tartrate powders, as well as by making mixed powders; that is, using two acid constituents in the same powder.

Objections to the use of alum baking powders. The use of alum baking powders has met with very considerable opposition on account of the poisonous properties of alum. For this reason the sale of baking powders containing alum has been prohibited in some states. It is doubtful, however, if any alum is ever present in the stomach after bread or cake is eaten which has been prepared with a baking powder containing alum. This is due to the fact that when such powders are moistened, the alum is decomposed by the sodium bicarbonate, with the liberation of carbon dioxide and the formation of sodium sulphate, potassium sulphate, and aluminium hydrate. While there is a possibility that by the action of the hydrochloric acid of the gastric juice these substances may again form alum, it is generally believed that this action does not take place to any great extent. The practice of adding alum to flour in order to produce a whiter bread is to be condemned. The substitution of ammonia alum in place of the more expensive potash alum in the manufacture of baking powders is also reprehensible. A great deal of baking powder is also made with sodium alum.

Wholesomeness of phosphate and tartrate powders. No objection of this kind has been raised against the phosphate and the tartrate powders. Phosphorus in some form is a necessary constituent of our diet, although it is doubtful if the system can assimilate this element from a phosphate. The tartrate powders are considered the most wholesome because the acid is obtained from such a commonly used fruit as the grape. Being an organic acid, it can be oxydized so as to furnish energy to the human system. By the action of the acid potassium tartrate on sodium bicarbonate when the baking powder is used, the compound sodium potassium tartrate, or Rochelle salt, as it is commonly called, is formed. This salt has a marked physiological action on the system, being laxative in its action, so that if a considerable amount of bread or cake which has been raised by a tartrate baking powder is consumed, its effect may be quite serious. The use of large quantities of bread or cake raised with baking powder seems to be attended with some liability of injury to the health, no matter what baking powder is used. The most wholesome bread is undoubtedly that raised by means of yeast.

EXPERIMENTS

35. Testing baking powders for alum. The presence of alum in baking powders may be tested for in the following manner: To a few grams of the powder 25 ccm. of water is added. When the gas has escaped, a few cubic centimeters of dilute hydrochloric acid is added and the starch which is insoluble is filtered off. To a small portion of the filtrate a few drops of barium chloride solution are added. A heavy white precipitate indicates the presence of sulphates, which constitute a portion of the alum.

To another portion of the hydrochloric acid solution caustic soda solution is added drop by drop. A white gelatinous precipitate may be calcium phosphate, aluminium phosphate, or aluminium hydroxide. Caustic soda is added until the solution is alkaline, and then a considerable excess is added and the solution warmed. If the precipitate dissolves entirely, calcium is absent and aluminium is present, which may be confirmed by adding hydrochloric acid until the solution is acid to litmus paper, and then making it alkaline with ammonia and warming. A white flocculent precipitate proves the presence of aluminium. If both sulphates and aluminium are found, alum was present in the baking powder. If the precipitate obtained with caustic soda does not give a clear solution with caustic soda, calcium may be present. In that case the solution is filtered and tested for aluminium as already directed, as the baking powder may have been prepared with both alum and calcium phosphate.

Aluminium may also be tested for by the following simple method: Place 2 gm. of the baking powder in a porcelain or platinum dish and heat with the Bunsen burner until the powder is burned to a nearly white ash. Extract with boiling water and filter. To the hot clear filtrate add ammonium chloride solution until a distinct odor of ammonia is given off. A white flocculent precipitate is evidence of the presence of aluminium.

Another simple test is carried out as follows: Logwood extract is prepared by covering some logwood chips with water and bringing to a boil. This is repeated four times, the last extraction being reserved for use. A few grams of the baking powder are treated with water. When effervescence ceases, the solution is made strongly acid with acetic acid and a few drops of the logwood extract added. A bluish-red color indicates the presence of alum.

36. Testing baking powders for phosphates. In order to make the test for calcium phosphate, the precipitate obtained in Experiment 35, which does not dissolve in caustic soda, may be used. It is dissolved in a few drops of hydrochloric acid, a few cubic centimeters of ammonium oxalate are added, and the solution made alkaline with ammonia. A finely divided white precipitate is evidence of the presence of calcium.

In order to test for phosphoric acid, a fresh portion of the baking powder is treated with water and the starch filtered off. Equal volumes of dilute nitric acid and ammonium molybdate solution are added and the mixture thoroughly shaken or stirred. A yellow, finely divided precipitate which forms somewhat slowly is evidence of the presence of a phosphate. If calcium has also been found, the presence of calcium phosphate has been proved.

37. Testing baking powders for tartaric acid. A baking powder may be tested for the presence of tartaric acid as follows: A solution of resorcin in sulphuric acid is prepared by dissolving 1 gm. in 50 gm. of concentrated sulphuric acid. Five gm. of the baking powder are treated with 250 ccm. of cold water. After allowing the carbon dioxide gas to escape and shaking thoroughly for a few minutes, the starch is filtered off and the filtrate evaporated to dryness on a water or steam bath so as to avoid charring the tartaric acid. A portion of the dry residue is treated with a few cubic centimeters of sulphuric acid solution of resorcin and warmed until the white fumes of sulphuric acid just begin to appear. If tartaric acid is present, the liquid assumes a beautiful wine-red color. The color disappears on the addition of water. As concentrated sulphuric acid, especially when hot, reacts rather violently with water, the acid should be allowed to cool and the water added very slowly.

Another portion of the dry residue obtained from the water extract of the baking powder may be tested as follows: The dry residue is dissolved in a few cubic centimeters of water, transferred to a clean test tube, and a few drops of silver nitrate solution added. On shaking for a few minutes a white crystalline precipitate is formed if tartaric acid is present. Dilute ammonia is added drop by drop until the precipitate is dissolved. The solution is diluted somewhat and the test tube placed in warm water. If a mirror of metallic silver is formed on the test tube, the presence of tartaric acid is indicated. A brown precipitate of metallic silver is also generally formed in the solution. If the test tube is not perfectly clean or the water too hot, the mirror may not form and only the brown precipitate be produced. It is advisable to carry out preliminary experiments on pure cream of tartar or tartaric acid, in order to become familiar with the method before making the test on a baking powder.

CHAPTER XVII

SPICES AND CONDIMENTAL FOODS

Importance of spices in the diet. Substances which are added to foods simply to give an agreeable flavor are called condimental foods. In most cases their nutritive value is very slight. They are of importance in the diet because they serve to stimulate the appetite and increase the flow of the digestive fluids. The digestive organs are to such an extent controlled by the nervous system, that in many cases little or no digestion takes place if food is introduced into the stomach in such a manner that the individual is not aware of being fed. This experiment has been repeatedly tried on animals. It has long been known that hasty eating, with little or no consciousness of the food being eaten, leads to indigestion. While many explanations have been given for this observation, probably one of the most important ones is the fact that under these circumstances the digestive organs are not properly stimulated.

Digestion stimulated by attractive foods. It is for a similar reason that the preparation of food so as to make it attractive in appearance is important. The color and odor as well as the taste of food, and pleasing surroundings, all tend to arouse the appetite, stimulate the flow of the digestive fluids and increase their strength.

Origin of condiments. Almost all substances used as condiments are of vegetable origin, the seeds, fruits, buds, flowers, bark, or roots being taken, depending upon the part of the plant which contains the aromatic principle. In many cases the flavor of the pure substance is not agreeable, but becomes so when added in proper quantity to other foods. Frequently a still finer flavor is obtained when several condimental substances are blended in foods, because a combination of several flavors seems to be most agreeable to the palate. Similarly, it has been found that the natural flavor of vegetable substances is generally due to the presence of several chemical compounds, many of which are volatile oils. In many cases these oils can be separated in pure form, such as clove, lemon, mustard, nutmeg oil, etc. Being volatile, they give agreeable odors, and if condiments are added to hot or boiling foods, much of the flavor is lost.

Allspice. This spice is the dried fruit of an evergreen tree which grows in the West Indies and is especially cultivated in Jamaica. The berries are gathered before they are fully ripe, as at this stage they give the best aroma. If the dried berry is broken open, it is found to consist of two cells, each of which contains a single seed. The principal constituents of allspice are a volatile oil (which produces the characteristic flavor), starch, tannin, mineral matter, protein, and crude fiber.

Cinnamon, or **cassia,** as it is often called, is the bark of a tree which is cultivated in the islands of Ceylon, Sumatra, and Java, as well as in some parts of tropical Asia. The thin inner bark of the tree is used, and comes into commerce in long cylindrical rolls of a brownish-yellow color. A cheaper grade, which is generally called cassia, is the bark of a tree which grows in China, Indo China, and India. As the outer bark is usually left on, this product is thicker and heavier than the Ceylon cinnamon. It is also of a darker color and coarser texture. Cassia buds are also found on the market, both whole and powdered, and are the dried flower buds of the China cassia.

The flavor of cinnamon is due to the presence of from 1 to 2 per cent of a volatile oil which has a very pungent and intensely sweet taste. A somewhat bitter taste is due to the presence of a small amount of tannin. Other constituents are starch (16–30 per cent), crude fiber, ash, protein, and water.

Cloves are the dried undeveloped flowers of the clove tree. This is an evergreen tree which is cultivated in Brazil, Ceylon, India, the West Indies, and other tropical countries. When the green buds begin to turn red, they are gathered and dried in the sun. They then acquire a deep brown color. On close examination of the clove, the four branching sepals can be seen surrounding the overlapping petals which inclose the stamens and pistil of the flower.

Composition of cloves. The strong pungent odor and taste is due to the volatile clove oil, of which from 10 to 20 per cent is present. The astringent taste is due to tannin, of which about 18 per cent is present. Mineral matter, starch, crude fiber, and protein constitute the remainder of the composition of cloves.

Cayenne pepper is the dried fruit pods of an herb which is cultivated in all temperate and tropical regions of the earth. A large number of species of the plant are known and cultivated, giving pepper varying considerably in color and pungency of flavor. The cayenne and chili varieties give long and slender pods of great pungency. The Hungarian red pepper is known as *paprika*, and is a very mild variety.

Composition of cayenne. While cayenne contains a small amount of oil, the pungent taste of this pepper is due to the presence of an alkaloid known as *capsicin.* The red coloring matter which is present in the pod is an important constituent. Fiber, ash, protein, etc., constitute the remainder of the pepper.

Ginger is the rootstock of an herb which grows to a height of from three to four feet. It is cultivated very extensively in India, China, tropical America, Africa, and Australia. Most of the ginger of commerce comes from Calcutta. When the plant is a year old and the stem has withered, the root is dug up. By different treatment of the root black or white ginger is produced. If the root when freshly dug is scalded to prevent sprouting and is dried at once, black ginger is produced. If, on the other hand, the bark is removed to prevent sprouting, white ginger is produced. It is sometimes made still whiter by bleaching or sprinkling with carbonate of lime. The white ginger is less aromatic and is generally considered inferior to the black ginger. This is largely due to the fact that the bark contains a large amount of pungent resin, which, together with a volatile oil, gives the characteristic flavor to the root. About 2 per cent of an aromatic oil and from 3 to 4 per cent of a fixed oil and resin is present. The remaining constituents are starch (about 50 per cent), crude fiber, protein, ash, and water.

Mustard is the seed of an herb which is cultivated extensively throughout the United States and Europe. There are two varieties, known as white and black mustard, although they are often known as yellow and brown mustard. The seed of black mustard is dark brown on the outside and yellow within, while that of white mustard is pale yellow. The ground mustard is generally a mixture of both species.

Composition of mustard. Both black and white mustard contain valuable ferments known as myrosin and sulphocyanate of sinapine. Black mustard also contains sinigrin, or myronate of potash, which is not found in white mustard, and which, upon being moistened with water under the action of the ferment also present in the seed, forms the volatile oil of black mustard. White mustard, on the other hand, contains a glucoside, sinalbin, not present in black mustard, which in the presence of water and the ferment myrosin also forms by hydrolysis an oil characteristic of white mustard.

Powdering of mustard. In preparing the ground mustard the seeds are first crushed and the hulls separated from the meats. In order to grind the latter a considerable portion of the fixed oil must be removed. This is done by subjecting the crushed seeds to hydraulic pressure. The press cake is then powdered.

Nutmeg and mace are obtained from the nutmeg tree, which is a native of the Malay Archipelago. The nutmeg of commerce is the seed obtained from the fruit of the tree. When gathered, the seed is surrounded with a thick covering. It is dried in the sun or by artificial heat for about two months. The outer covering dries and becomes separated from the kernel and can be easily broken loose. It is known in commerce as mace. The nut is washed in milk of lime and dried or sprinkled with dry air-slacked lime. This treatment is said to prevent sprouting and to ward off the attacks of insects. Some nutmegs are sent into commerce without the lime treatment, and are known as brown nutmegs. Nutmegs differ in shape from nearly spherical to an elongated oval shape.

Composition of nutmegs. Nutmegs contain from 2.5 to 4 per cent of a volatile oil, 31 to 37 per cent of fat, 30 to 40 per cent of starch, 7 to 10 per cent of crude fiber, about 5½ per cent of albuminoids, 2 to 3 per cent of ash, and 4 to 12 per cent of water. The composition of mace is very similar to that of nutmegs.

Wild mace. The most common adulterant of mace is the so-called false or wild mace, commonly known as Bombay mace. It is almost entirely devoid of odor and taste, and therefore lowers the strength of true mace when mixed with it.

Pepper is the dried berry of the pepper plant, which grows in the East Indies and other tropical countries. It is a climbing shrub, which grows to a height of from twelve to twenty feet. When the fruit begins to turn red, it is gathered and dried. It then shrivels up and turns black. There are a good many varieties of black pepper which have been named from the localities from which they are produced or from which they are shipped, such as Singapore, Sumatra, Malabar, Penang, Mangalore, etc.

White pepper. If the pepper berry is allowed to ripen and the skin removed, white pepper is produced. In some cases white pepper is produced by removing the skin from black pepper. White pepper is named in the same manner as the black varieties, such as Siam, Singapore, Penang, etc. The pungent taste of pepper is produced by an essential oil known as pepper oil, of which from 0.5 to 2 per cent is present. There is also present from 6 to 10 per cent of a nonvolatile oil. The odor and sharp, biting taste of pepper is partly due to the presence of two alkaloids, *piperidine* and *piperine*, of which about 5 per cent is present. From 30 to 60 per cent of starch, ash, water, and protein constitute the remainder of the spice.

Adulteration of spices. On account of their high price, spices have been subjected to a great deal of adulteration. This is especially true of powdered spices, to which a great variety of inert powdered material can be added without much fear of detection by the average consumer. Commonly used material of this kind includes the ground shells of most nuts, such as English walnuts, Brazil nuts, almonds, coconuts, etc. Easily obtained waste products of various foods, such as cocoa shells, buckwheat hulls, ground olive, and date stones, are frequently used; while spruce, oak, and red-sandalwood sawdust has at times been found. A microscopic examination will frequently show the presence of these foreign substances. A given spice will be mixed with the adulterant, which most nearly resembles it in color and general appearance. In many cases the color is imitated by means of a dye. Turmeric, for instance, can be used to produce a color similar to that of mustard. Starch and various cereal flours have also been considerably used. The ground bark of various trees, more especially the elm, has been used to adulterate ground cinnamon. Ground pepper shells, stems, and sweepings are frequently added to ground pepper. Such material is known in the trade by the symbol "P.D." (pepper dust), and this symbol has been adopted to designate any material suitable for the adulteration of pepper or other spices.

Grinding nutmegs. Ground nutmegs are subjected to a rather peculiar adulteration. As it is difficult to grind whole, sound nutmegs on account of the rather large amount of oil present, a special grade, known as "grinding nutmegs," has been used to some extent. These are moldy, worm-eaten, fragmentary nutmegs, which are imported for the purpose of grinding. When detected, the importation or sale of such spices is prevented.

Exhausted spices. Although powdered spices are far more commonly adulterated than the whole spice, some adulteration of the latter has been practiced. Where the oil or other flavoring matter of a spice can be extracted and sold, the completely or partially exhausted spice is sometimes sold. Aside from a slightly wrinkled or shriveled condition, the general appearance of such spices is the same as that of spices which have the full flavoring strength. The detection of this adulteration is more difficult when such exhausted spices are mixed with those of full strength. The exhausted spice is also ground and mixed with the ground, pure spice, very materially reducing the strength of the latter. As there is a good market for clove oil, this spice has been largely subjected to this form of adulteration. The same is true of ginger, because the extract of this spice is largely used.

Microscopic examination of spices. A great many of the forms of adulteration of spices may be detected by examination under the microscope. For this purpose a magnification of about 125 diameters is sufficient. Samples of pure whole spices are ground and compared with the ground spice as purchased.[1]

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[1] For further information on this subject, the reader is referred to Winton's "Microscopy of Vegetable Foods" and Leach's "Food Inspection and Analysis."

CHAPTER XVIII

FLAVORING EXTRACTS

Utility of flavoring extracts. A number of vegetable substances contain flavoring matter which can be extracted. This is advantageous because such extracts are more convenient for use, and undesirable portions of the vegetable substances need not be introduced into the food. In some cases both the extract and the whole vegetable product is in use. By means of these highly flavored substances many wholesome and nutritious foods which are quite lacking in flavor are made very palatable. Vanilla and lemon are by far the most commonly used flavoring extracts.

The vanilla bean. Vanilla extract is made from the vanilla bean. This bean is the fruit of the orchid *Vanilla planifolia.* It is a climbing parasite, which fastens itself to the bark of trees in moist tropical climates. It is indigenous to Central America and the West Indies, but the finest beans are produced in Mexico. It is frequently cultivated together with the cacao tree, as both the vanilla vine and the cacao tree require a rich soil, shade from large trees, and a warm climate. While the vine clings to the tree, it obtains its nourishment from the air through its tendrils and aërial rootlets. It blossoms in October and November, and the pods are gathered in May, June, and July. The pods are green at first, and when they turn brown are ready to be gathered. The drying of the pods is the most important part of their preparation for market, as it is during this process that the flavor is developed. When picked, the beans are without odor, but this develops during a process of fermentation or sweating. The drying in the sun requires about a month, and is said to give the best product.

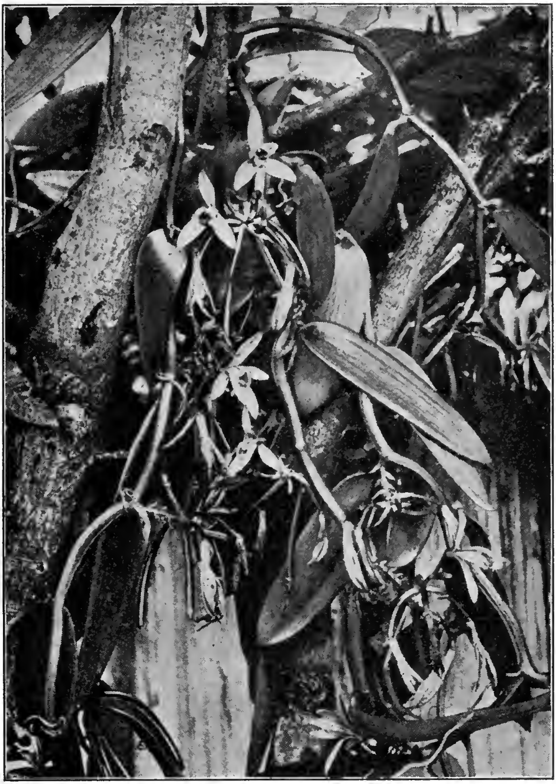

FIG. 30. The Vanilla Vine, showing Leaves, Flowers, and the Vanilla Beans, as well as the Tree to which the Vine clings

Recently an artificial method of drying by means of air dried over calcium chloride has come into use. This process gives a much more uniform product.

Preparation of vanilla extract. When the curing and drying process is completed, the beans are tied in bundles and sent to market, where the best quality commands very high prices, sometimes reaching fifteen dollars per pound, although four to six dollars is a more common price. The extract is prepared by treating the beans with strong alcohol and sugar. For this purpose they are cut up into rather small pieces and soaked in the alcohol for some time. The alcoholic extract is drained off and bottled for the market. To a limited extent the beans are sold for use in foods, small portions being cut off and put into the food to be flavored.

Varieties of vanilla bean. A considerable number of different varieties and grades of beans are found on the market. The Mexican vanilla beans are considered the best, being from 8 to 10 inches long and from $\frac{1}{6}$ to $\frac{1}{3}$ inch thick. They are dark brown in color and feel waxy to the touch. The Bourbon beans, which are shorter than the Mexican, are considered next in grade. They are grown in the Isle of Réunion. Still shorter and cheaper beans are grown in Mauritius and South America. The shorter beans are the Tahiti or wild vanilla beans.

Vanillin. The peculiar flavor of the vanilla bean is very largely due to the presence of a white crystalline substance which is known as vanillin. Crystals of this compound may frequently be seen on the outside of the vanilla beans. This substance has been artificially prepared by chemists and is manufactured in large quantities. A number of other substances are also present, which modify and improve the flavor. These substances are known collectively as resin, 4 to 11 per cent being present in vanilla beans. There are also present considerable quantities of wax, sugar, tannin, and gum. Although the flavor of the beans is largely due to the presence of vanillin, the most highly prized varieties do not contain the largest percentage of vanillin, as is shown by the following table:[1]

TABLE XXIX

Vanillin in Vanilla Beans

	Per cent
Mexican beans	1.69
Bourbon beans	2.48
Java beans	2.75

Pure vanilla extract contains from 0.1 to 0.2 per cent of vanillin, about 20 per cent of sugar, 40 per cent of alcohol, and 2 to 4 per cent of other extractive matter, including the vanilla resins. Some extracts are prepared with glycerin instead of sugar.

The tonka bean. This bean has been very largely used in place of the more expensive vanilla bean in making extracts. It is the seed of a large tree which is native to Guiana. The tonka bean is almond-shaped, and dark brown or black. The flavoring matter in this bean is an entirely different substance from that present in the vanilla bean. It is known as coumarin and has a much sharper and less pleasant odor than vanilla. It is a white crystalline powder in the pure state. The flavoring matter is extracted from the tonka bean in exactly the same manner as from the vanilla bean. The extract is generally of a darker color than true vanilla extract. It also contains resinous matter somewhat similar to that of the vanilla bean.

Tonka extract. While tonka extract is often sold as vanilla extract, a much more common practice consists in substituting tonka beans for a portion of the more expensive vanilla extract. Both such mixed extracts and the pure

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[1] Leach, Food Inspection and Analysis, 1909, p. 857.

tonka extract find a ready sale, because coumarin, the flavoring matter of the tonka bean, has a much sharper odor, giving the extract greater flavoring power, unless delicacy of flavor is desired. The sale of the tonka extract or mixed tonka and vanilla extract is not illegal unless those preparations are sold as pure vanilla extract. They must be labeled "Tonka Extract" or "Tonka and Vanilla Extract," so that the purchaser clearly understands what he is buying.

Artificial extracts. As both vanillin and coumarin are manufactured on a large scale and can be sold a great deal cheaper than the natural flavoring matter, a great deal of so-called flavoring extract has been made and sold which contains no extract at all of vanilla or tonka beans. Such artificial or compound extracts are prepared by dissolving vanillin or coumarin crystals and sugar in alcohol and water and adding some appropriate coloring matter. Caramel or burned sugar has been very largely used as coloring matter. Recently prune juice, which is an alcoholic extract of prunes, has been sold under various trade names and used to some extent as coloring matter. In many cases a small quantity of vanilla or tonka extract is added to give color and flavor.

The table on page 185 gives the composition of a number of vanilla extracts as purchased on the market.

A true vanilla extract should contain about 38 per cent of alcohol and between 0.1 and 0.2 per cent of vanillin. Coumarin should be absent.

Lemon extract is a solution of the flavoring matter of lemon peel in alcohol. It is prepared by subjecting lemon peel to the action of strong alcohol. The flavoring matter in the lemon peel is a volatile, fragrant oil, which is soluble in alcohol. When pure, the oil is almost colorless, but sufficient coloring matter is dissolved by the alcohol to

TABLE XXX

Composition of Vanilla Extracts as Purchased

Volume[1]	Solids	Ash	Alcohol	Vanillin	Coumarin
Ccm.	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
47	6.55	0.18	16.1	0.095	
	12.01	0.39	37.7	0.10	
	21.15	0.34	28.9	0.059	
	13.52		13.0	0.23	0.38
	12.49	0.14	25.37	0.21	
54	9.71	0.09	15.00	0.06	
47.5	7.73	0.2	20.00	0.28	
	11.40	0.05	18.00	6.02	0.03
	14.13	0.32	28.30	0.15	
46	8.51	0.29	23.16	0.05	
53	10.72		10.44	0.05	0.07
	4.13	0.05	9.85	0.15	0.093
	13.25	0.12	14.93	0.15	0.07
26.5	10.70	0.32	28.60	0.10	
56.5	9.65	0.45	45.36	0.155	
57.5	14.12	0.17	22.35	1.12	0.02
60	13.10	0.20	18.42	0.27	
57	14.05	0.36	17.01	0.15	
	10.53	0.02	9.84	0.842	0.07
	10.55	0.29	36.7	0.168	
17	44.0	0.50	18.77	5.96	1.82

give the extract a light yellow color. The pure lemon oil is prepared in large quantities from the fresh lemon peel by pressing the peel against a rough sponge which is kept moist with water. As the oil floats on the water, it is easily separated and purified. A great deal of lemon extract is prepared by dissolving this oil in alcohol and coloring the solution with a strong alcoholic extract of lemon peel. In some cases coal-tar dyes or other yellow coloring matter

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[1] Two ounces is equal to 57 ccm. The ordinary bottle of vanilla extract is understood to be a two-ounce bottle.

is added. The United States standard for lemon extract is 5 per cent of lemon oil by volume. There are many brands of lemon extract on the market containing more than this amount of oil.

Adulteration of lemon extract. This consists almost invariably in the reduction of the amount of lemon oil present. This results from the fact that the most expensive constituent of the extract is the alcohol. In order to hold 5 per cent of lemon oil in solution, at least 80 per cent of alcohol must be present. In attempting to reduce the amount of alcohol in the extract, the amount of lemon oil held in solution becomes less and less, until with 45 per cent of alcohol practically no oil at all can be present. Such an extract will, however, give a very distinct odor of lemon, and if colored yellow will find a ready sale. The absence of lemon oil can easily be shown by adding twice the volume of water. If the mixture remains clear, no oil can be present. Extracts of standard strength give a white milky liquid, due to the particles of oil held in suspension. The amount of oil present is proportional to the degree of cloudiness produced. Methyl alcohol has also been used instead of ethyl alcohol in making lemon extract.

Orange extract is prepared from orange peel by a method similar to that used in the preparation of lemon extract. It is an alcoholic solution of orange oil. It should contain at least 5 per cent of orange oil.

Almond extract is an alcoholic solution of the oil of bitter almonds, and should contain at least 1 per cent of this oil. The oil must first be extracted from the almonds and purified in order to free it from the poisonous hydrocyanic acid.

Other flavoring extracts. Extracts of a number of other aromatic vegetables are on the market, as well as extracts of very nearly all the common spices. Generally these extracts are alcoholic solutions of the oils which give the characteristic flavor to the spices.

Fruit flavors. Attempts to extract the natural flavoring matter in fruits have in most cases been unsuccessful. Practically all of the fruit essences on the market are artificial mixtures of chemical compounds, which imitate more or less closely the natural fruit flavors. Several chemical compounds have been prepared, which have an odor remarkably similar to that of some fruits. Such substances are amyl acetate, having an odor like bananas; butyric ether, resembling the odor of pineapples; and amyl valerianate, sometimes called apple oil. These substances are compounds of various organic acids, and alcohol. In other cases where no single substance has been found the odor of which closely resembles that of the fruit to be imitated, a mixture of several chemical substances is made to imitate the natural flavor. If no poisonous substances are present, and if not sold as pure fruit flavors, the sale of such artificial fruit flavors is not illegal.

APPENDIX

CHEMICALS AND REAGENTS

The amount of each chemical given is in all cases sufficient for the performance of all the experiments given in the test for which it is required. In a good many cases it is much more than necessary and would be sufficient for a large class. It is often not economical to purchase chemicals in very small quantities. All chemicals in this list, as well as the apparatus given in the following list, may be purchased of Eimer & Amend, Third Avenue and 18th Street, New York.

Acetic acid (½ lb.). The strongest commercial quality of this acid is known as glacial acetic acid and is very nearly 100 per cent pure. Dilute acetic acid is prepared by adding 40 ccm. of the glacial acid to 100 ccm. of water. This strength is commonly used.

Agar-agar. This is a dried seaweed which has the property of absorbing a large amount of water and solidifying into a jelly.

Ammonia (1 lb.). The concentrated c.p. solution as purchased must be diluted with 2 volumes of water for ordinary use. It should be kept in a glass-stoppered bottle. If acid of any kind is accidentally spilled on clothing, ammonia should be applied.

Ammonium molybdate (1 oz.). A white crystalline salt used in nitric acid solution as a test for phosphoric acid, which produces a yellow, finely divided precipitate. The solution is prepared as follows: 7½ gm. of ammonium molybdate are dissolved in 50 ccm. of water with the addition of a little ammonia if necessary. This solution is poured with constant stirring into a mixture of 25 ccm. of concentrated nitric acid and 25 ccm. of water. The solution is placed in a glass-stoppered bottle and allowed to stand for several days. The clear liquid is added to the solution to be tested for phosphoric acid.

Amyl alcohol (½ lb.). A colorless liquid.

Barium chloride (1 oz.). White crystals. A solution is prepared by dissolving 1 oz. in 200 ccm. of water.

Borax (1 oz.). A white powder.

Bromine (1 oz.). A dark red, fuming, highly corrosive liquid. Great care should be taken not to allow liquid bromine to come in contact with the skin nor to breathe the fumes. A few drops are placed in a glass-stoppered bottle, which is filled with distilled water and well shaken. This saturated solution is called bromine water.

Carbon disulphide (½ lb.). A heavy volatile liquid.

Caustic soda (½ lb.). A white solid usually sold in sticks. Both the solid caustic and the solution should be kept well stoppered, as the carbon dioxide of the air converts it into sodium carbonate. The caustic soda solution is prepared by dissolving 20 gm. in 100 ccm. of water.

Ether (½ lb.). A very volatile, highly inflammable liquid. The vapor forms an explosive mixture with the air. It should be kept in a bottle stoppered with a well-fitting cork, preferably in a cool place. It should never be handled near a flame of any kind.

Fehling's solution. This is an alkaline solution of copper, which is used to test for reducing sugars, such as dextrose, levulose, etc. When the solution is boiled with such sugars, the copper is reduced to the cuprous condition, which is indicated by the change from a blue transparent solution to a bright red precipitate. The solution is prepared immediately before it is used by mixing equal portions of two solutions A and B, which are prepared as follows:

A. Dissolve 7 gm. (about ¼ oz.) of crystallized sulphate of copper in 100 ccm. of water.

B. Dissolve 34.6 gm. of crystallized Rochelle salt in 45 ccm. of water, also 25 gm. of caustic soda in 40 ccm. of water. Mix these two solutions and dilute to 100 ccm.

Ferric chloride (1 oz.). A red solid easily soluble in water. The solution is prepared by dissolving 5½ gm. in 100 ccm. of water.

Ferrous sulphate (1 oz.). A green crystalline salt. As it is not stable in solution, a few crystals are dissolved in water when needed.

Gelatin (gold label).

Hydrochloric acid (also known commercially as muriatic acid) (1 lb.). The acid as purchased is a solution in water of the pure acid, which is a gas. The strongest acid sold contains about 40 per cent of acid. This solution is a fuming corrosive liquid. If spilled on the hands, it is washed off with water. If spilled on the clothing, it should be neutralized with ammonia and then washed out with water.

A dilute solution for ordinary use is prepared by mixing 5 volumes of the strong acid with 8 volumes of water.

Iodine (1 oz.). A gray-black crystalline solid, which slowly volatilizes at ordinary temperatures. It acts on the skin and most organic matter. It is readily absorbed by ammonia. It is soluble in alcohol and a water solution of potassium iodide. The potassium iodide solution gives a blue color with starch. It is prepared as follows: 2 gm. of iodine are agitated with a solution of 6 gm. of potassium iodide in a few cubic centimeters of water. When the iodine is entirely dissolved, the solution is diluted with water until its volume is 100 ccm. It should be kept in a glass-stoppered bottle.

Lead acetate (1 oz.). A white crystalline solid. By heating a water solution with lead oxide basic lead acetate is produced, which is used to precipitate fruit juices and other soluble organic matter. The solution is prepared as follows: 18 gm. of lead acetate are dissolved in 70 ccm. of hot distilled water and 11 gm. of lead oxide added. The mixture is boiled for half an hour with occasional stirring, after which it is allowed to settle for a few minutes and the clear solution poured off or filtered. Enough distilled water is added to make the volume about 81 ccm. The solution must be kept in well-stoppered bottles. A dilute solution made by adding about 4 volumes of water to 1 volume of the strong solution is suitable for ordinary use.

Lead oxide (1 oz.). A heavy yellow to orange powder.

Limewater. A saturated water solution of calcium oxide. It is prepared by treating a few ounces of ordinary lime with water, shaking thoroughly, and allowing to stand until the insoluble matter has settled. The clear liquid is siphoned off or decanted into a bottle, which should be kept well stoppered.

Litmus paper. A sheet each of blue and red should be purchased and cut into strips of convenient size. The paper is used to test for acids and alkalies. Acids turn the blue paper red, while alkalies or bases turn the red paper blue.

Magnesium (½ oz.). A white metal which is sold in the form of narrow ribbons.

Methyl alcohol (1 pt.). Also known as wood alcohol. A volatile combustible liquid.

Methyl orange (1 oz.). A yellow powder soluble in water and used as an indicator for acids and bases. Acids give a red color to the solution, while alkalies give a yellow color. The solution is prepared by dissolving 1 gm. in 1000 ccm. of distilled water.

Nitric acid (1 oz.). The pure acid is a fuming, corrosive liquid, generally colored reddish on account of the presence of nitrous acid. It acts rapidly on wood, cloth, the skin, and most organic matter. The ordinary concentrated acid contains about one third its weight of water. For many purposes a dilute acid is prepared by adding 2 volumes of water to 1 volume of the concentrated acid.

Phenolphthalein (1 oz.). A white crystalline solid used in alcoholic solution as an indicator for acids and bases. In acid solution the indicator is colorless, while alkalies give a deep red color. The solution is prepared by dissolving $\frac{1}{10}$ gm. in 100 ccm. of alcohol.

Phosphoric acid (1 lb.). In its most concentrated form (glacial phosphoric acid) this acid is a thick sirupy liquid. For ordinary use a dilute solution, prepared by adding 3 volumes of water, is sufficiently concentrated.

Resorcin (1 oz.). This organic compound is used in testing for tartaric acid. One gram is dissolved in 50 gm. of concentrated sulphuric acid. When heated with even a very small quantity of tartaric acid this solution gives a beautiful wine color.

Rochelle salt (2 oz.). This is the sodium and potassium salt of tartaric acid. It has the property of holding copper in solution in the presence of an alkali, and is therefore used in Fehling's solution.

Silver nitrate (1 oz.). A white crystalline salt, very soluble in water. A solution of convenient strength may be prepared by dissolving 3½ gm. of the salt in 100 ccm. of water. The solution should be kept in a glass-stoppered bottle made of dark-brown glass; or, if this is not at hand, the solution should be protected from the light by pasting dark paper around the bottle.

Sodium (metallic) (1 oz.). In the pure state this element is a soft silvery-white metal. It oxidizes very rapidly in the air and reacts violently with water. It is therefore sold in sealed tin cans, and must be kept under kerosene or other mineral oil. The oil can be removed from the sodium by means of dry filter paper. The metal can easily be cut with a clean dry knife. It should not be left exposed to the air or moisture for any length of time.

Sodium carbonate (dry) (1 lb.). A white powder, very soluble in water, composed of sodium and carbonic acid. Its solution is strongly alkaline and neutralizes acids.

Sodium acid sulphite (½ lb.). A white salt, very soluble in water, composed of sodium and sulphurous acid. It is largely used as a preservative.

Starch iodate paper. Starch paste is prepared as directed on page 15. A small quantity of potassium iodate is dissolved in water and added to the starch paste. Strips of filter paper are dipped into the mixture and hung up to dry. Sulphur dioxide (fumes of burning sulphur) or sulphurous acid turns the paper dark blue and then bleaches it.

Sulphur (1 oz.). A yellow solid found on the market in rolls or as a powder (flowers of sulphur). Roll sulphur is the form most soluble in carbon disulphide.

Sulphuric acid (1 lb.). In the pure state this acid is a thick, heavy, viscous liquid. It chars paper, wood, and most organic matter and reacts violently with water. If spilled on the clothing, ammonia should be applied; if on the skin, it should be immediately washed off with cold water. For ordinary use dilute acid should be prepared by diluting 1 volume of the concentrated acid with 6 volumes of distilled water. The water must not be poured into the acid, because the large amount of heat developed is liable to produce violent boiling and spattering of the acid. When it is poured slowly and with constant stirring into the water, no violent action takes place. Both the concentrated and dilute acid should be kept in glass-stoppered bottles.

Turmeric paper. This paper may be purchased or it may be prepared by dipping strips of filter paper into an alcoholic solution of turmeric and allowing them to dry. Alkalies turn the paper red. It is most largely used to detect boric acid. When dipped into a solution of this acid to which hydrochloric acid has been added, and then dried, a bright red color is produced, which is turned green by alkalies. The paper must not be dried at a temperature above 100° C. or that of boiling water.

Witte's peptone (½ lb.). A white powder used in the preparation of nutrient gelatin.

Wood alcohol (1 lb.). Also called methyl alcohol. A colorless, volatile liquid obtained by dry distillation of wood.

APPARATUS

The following list includes all the apparatus necessary to prepare most of the experiments given in the text. The more expensive apparatus which would be required in order to perform a few of the most difficult experiments is given in a separate list.

Air oven. This piece of apparatus consists of a copper oven which can be heated with a Bunsen burner. A suitable opening in the top is provided for the insertion of a thermometer, so that the temperature can be regulated to suit the substance to be heated or dried in the oven. For many purposes an ordinary gas oven is entirely satisfactory.

Beakers. Thin glass vessels in which liquids may be boiled. They may be obtained in a great variety of sizes. For ordinary use, nests of beakers having capacities of 2, 4, 6, 8, 10, and 12 oz. are satisfactory.

Bottles. One and one-half dozen glass-stoppered bottles of 250 ccm. capacity.

Bunsen burner. In the absence of a suitable stove, Bunsen burners are convenient. They are attached to gas jets by means of rubber tubing.

Filter paper. Circular paper may be obtained in packages of 100 sheets of various sizes. Paper of 12½ or 15 cm. in diameter is convenient.

Flasks. The so-called Florence flasks are flat-bottomed and suitable for most purposes. A convenient size is 8 oz.

Funnels are used for holding the paper when filtering. Size 3 to 4 in.

Graduates are tall vessels on which the capacity in cubic centimeters is marked, and are used for measuring liquids. Size 100 ccm.

Pipestem triangles are wire triangles covered with clay tubing, and are used for holding vessels while being heated with the Bunsen burner. Size 3 to 4 in.

Platinum wire (1 ft.). This metal resists the action of most chemical reagents and cannot be melted or oxydized in the gas flame. The wire is used for inserting drops of solutions to be tested in the flame of the Bunsen burner. Size No. 25.

Porcelain dish. These dishes are suitable for evaporating liquids, and may be subjected to the full heat of the gas flame. Size 3 in.

Porcelain mortar. Suitable for grinding or mixing chemicals. Size 3 in.

Test tube (½ gross). Suitable for a great variety of tests on small quantities of liquid. They may be heated in the Bunsen-burner flame. Size 6 in.

Thermometers. Chemical thermometers have the scale etched on the glass tube and are made entirely of glass. 360° C.

Tripod (2). An iron stand suitable for the support of beakers or other vessels which must be heated with the Bunsen burner. A wire gauze should be placed on the tripod in order to distribute the heat of the Bunsen burner and to serve as a support for the beaker.

Water bath. A copper or iron vessel suitable for boiling water, and fitted with a lid composed of rings so that vessels of various sizes may be heated by the steam. As the temperature of the steam is 100° C., the vessel heated or its contents cannot rise above this temperature.

Wire gauze (½ doz.). Four-inch squares of iron or copper are suitable for most purposes. Wire gauze transmits the heat of a gas flame, spreading it over a large surface and protecting the vessel heated from direct contact with the flame.

SPECIAL APPARATUS REQUIRED FOR SOME OF THE MORE DIFFICULT EXPERIMENTS

Balance. The ordinary analytical chemical balance is a very delicate instrument, and, with a set of weights, can be purchased for from $50 to $150. Fairly satisfactory results could be obtained with a cheaper instrument, which would be somewhat less sensitive.

Burette (2). An instrument consisting of a glass tube graduated to tenths of cubic centimeters and having a stopcock attached, so that any desired quantity of liquid may be delivered. The usual capacity is 50 ccm.

Casserole. A cup-shaped porcelain vessel provided with a handle and suitable for heating liquids, especially when it is desirable to keep the liquid agitated. A very convenient size is 250 ccm.

Petri dish (1 doz.). These are flat, circular glass dishes provided with glass covers. They are used for making bacterial cultures and counts.

Pipettes. Glass tubes having a bulb at the center and marked to deliver a definite quantity of liquid, such as 1 ccm., 5 ccm., 10 ccm., 25 ccm., etc. For bacteriological work 1-ccm. pipettes are used, two dozen being a suitable quantity. Half a dozen pipettes graduated so as to deliver either 9 or 10 ccm. would also be required. These pipettes must be sterilized and kept in a sterilized receptacle until used. For this purpose tin or copper cans of suitable size, provided with a lid or long test tubes, must be employed. The latter may be closed with a plug of cotton.

Platinum. This metal is eminently suited for chemical work because it is unaffected by most chemical reagents, and can be heated to the highest temperature obtained with the gas flame without injury. In making food tests platinum dishes about 3 in. in diameter are very useful for burning the organic matter of foods. Tests on smaller quantities can be carried out on platinum foil, which can also be used for the deposition of copper, for which purpose platinum dishes are also well adapted.

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